THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. 40 NOVEMBER, 1938 No. 5

THE CHROMOPHOBE ADENOMAS OF THE PITUITARY

PATHOLOGIC FEATURES AND RESPONSE TO IRRADIATION BASED ON A STUDY OF 81 VERIFIED CASES*

By MAX T. SCHNITKER, M.D., TOLEDO, OHIO, ELLIOTT C. CUTLER, M.D., BOSTON, MASSACHUSETTS, ORVILLE T. BAILEY, M.D., CAMBRIDGE, MASSACHUSETTS, *and* WALTER W. VAUGHAN, M.D., DURHAM, NORTH CAROLINA

STUDY of tumors of the pituitary gland received an impetus from the investigation of the physiology of that organ in the latter part of the nineteenth century. The adenoma of acidophile cells was first clearly differentiated from other pituitary tumors by Benda[3] in 1900. The classic monograph of Cushing[6] in 1912 initiated the modern period of study of pituitary lesions by its descriptions of patients whose tumors were accompanied by hyperpituitarism and by hypopituitarism. Cushing's investigations were of special importance in their emphasis on the value of studies on the same patient in the clinic and in the laboratories of physiology and pathology.

Since that time progress has been made in all these fields, and especially in modes of treatment. Experience has shown that complete surgical removal of tumors of the pituitary is usually impracticable. Considerable benefit has resulted in the past from partial removal of these neoplasms by operation. Within the last decade improved methods of roentgen therapy have produced results which indicate that it is a valuable agent in the treatment of tumors of the pituitary (including chromophobe, acidophile and basophile types).

Gramegna[11] (1909) was the first to report the successful treatment of a patient with a pituitary adenoma (acromegaly) by irradiation alone. Béclère,[2] in the same year, treated a similar condition with success in a girl of sixteen; this patient was in perfect health thirteen years later (1922). Heinismann and Czerny[13] reported the first large collected series of patients with pituitary adenomas who were treated by irradiation alone. The 73 tumors were unverified and included pituitary disorders of many types. In these cases the most satisfactory results were obtained in the acidophile adenoma group (acromegaly) and the "mixed type" with symptoms of optic nerve compression. The group with the adiposogenital (Froehlich) syndrome showed less improvement. Since 1930 a large number of papers have appeared dealing with the treatment of pituitary adenomas by irradiation.[4,8,10,12,14,15,16] Of the three types of adenomas now recognized, the basophile adenoma is considered most susceptible to irradiation, while the acidophile adenoma

* From the Departments of Surgery and Pathology of the Harvard Medical School and the Peter Bent Brigham Hospital, Boston, Mass. Read in part at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

is thought to be somewhat less responsive, though it is distinctly altered by this form of treatment in most cases.

Discussion of the importance of irradiation in dealing with chromophobe adenomas of the pituitary is still unsettled since the degree of improvement following such treatment has been variable and the evidence difficult to evaluate. Surgeons have continued to emphasize the surgical approach as a treatment of choice, while radiologists have urged roentgen therapy. Both groups have shown striking results, but the surgeons have been able to draw their statistics from a much larger number of patients. Several authors with wide experience[1,9,17, and others] now favor a trial of irradiation in selected cases of chromophobe adenoma, especially in those with slightest impairment of vision. They resort to surgery if irradiation proves inadequate. It is widely taught that all patients subjected to operation should receive roentgen therapy postoperatively.

The purpose of this study is to make an analysis of a series of patients suffering from chromophobe adenomas of the pituitary—to follow the clinical progress of the patients, subsequent to surgical and roentgen treatment, and to study the histologic structure of the tumors. Finally, an effort has been made to correlate the data from each source so far as possible. The series includes 81 instances of chromophobe adenoma verified by operation, which have been studied at the Peter Bent Brigham Hospital between January 1, 1928 and January 1, 1936. It was in 1928 that the present roentgen-ray unit was installed in the hospital and a relatively uniform technique of therapy has been carried out to the present time. In addition, there were 7 patients who received roentgen therapy only, and whose neoplasms were unverified in consequence. Of the 81 verified cases, 42 received some irradiation before or after operation, and 39 received operation alone without irradiation. In consideration of the entire group of 88 cases, 54 were males and 34 were females, ranging in age from eighteen to seventy-one years, with an average age of forty years (Chart 1). Twenty-one of the 88 patients in the series were Hebrew. All were of the white race.

The present group of patients gives no indication of the frequency of chromophobe adenomas among all pituitary tumors. Numerous reports are available to supply these data. Neoplasms of the posterior lobe are rare. In a series of 385 cases of pituitary adenomas reported by Cushing[6] the types of adenomas occurring in the anterior lobe were divided as follows:

1. Chromophobe adenomas	73%
2. Chromophile adenomas	20%
3. Mixed type	7%
4. Basophile adenomas	Rare

An attempt has been made to trace the life history of the chromophobe adenoma. The following account is derived from a study of our cases and from available data in the literature.

The chromophobe adenoma is a non-secreting tumor of an endocrine organ. Consequently it does not produce any recognizable constitutional disorder until it reaches a size sufficiently great to destroy a large part of the normal tissue of the gland in which it is situated. As the tumor grows, it compresses the remaining normal portions of the pituitary gland against the bony wall of the sella turcica so as to interfere with the pituitary secretory function (Fig. 9). The symptoms that follow the slow inactivation by compression are those of hypopituitarism. This differs in no respect from Froehlich's syndrome except for its slower and later onset. If such a tumor occurred in a child, the clinical picture would be that of a "pituitary dwarf."

The symptoms associated with the chromophobe adenomas can be divided conveniently into two groups—the *glandular* and the *neighborhood* symptoms:

1. The *glandular* symptoms are those of hypofunction. In the male the syndrome begins with lack of energy and easy fatigue. However, he usually complains first of decrease in libido. Sexual activity later dis-

appears entirely. In the female the syndrome usually begins with amenorrhea and sterility. Occasionally it has its onset after pregnancy. Patients of both sexes develop an increase in body weight with an accumulation of subcutaneous fat about the breasts and over the hips. As an end-result of this process, the body takes on the configuration seen in infancy and early childhood. The hands are short and fingers tapering. The skin grows dry, pale and soft. The hair becomes thinned, especially at the sides of the forehead, and finally falls out. Its texture is more silky than it was before the development of the tumor. The basal metabolic rate is usually below normal. Fifty of our group showed a rate below −15 per cent, the lowest being recorded as −37 per cent, and the highest +10 per cent.

2. The *neighborhood* symptoms are mainly visual disturbances and headaches. As the tumor grows, the bony wall of the sella turcica is gradually eroded and pushed out (Fig. 7). At this point it has the appearance described by radiologists as "ballooned sella." During this time the distention of the sella or the pull on the adjacent dura produces headache. This was the presenting symptom in 7 of our patients. When the tumor finally breaks through the sella, the headaches often disappear. The visual disturbances are a more serious result of changes on neighboring structures occasioned by the growth of the tumor. Seventy-seven of the 88 patients in this series entered the hospital because of failing vision. Eighty-six had some defect in the field of vision, the other 2 showing no defect although both patients had large tumors. Failing vision is by far the most important early symptom of the condition. The tumor occasions these disturbances in vision by growth upward out of the sella turcica. It then presses against the overlying optic chiasm and elevates it. Since the pressure first causes impingement on the posterior portion of the optic chiasm, the initial defect in the visual fields is in the upper temporal quadrants. As the pressure increases, the defect is enlarged to a complete bitemporal hemianopsia. This is the condition usually found when a patient suffering from chromophobe adenoma first consults his physician. Still later the nasal fields fail and finally total blindness results, when pressure on the optic nerves destroys all fibers. Occasionally, the tumor breaks through the lateral wall of the sella turcica and presses against the medial portion of the temporal lobe, involving the optic radiation fibers posterior to the chiasm. In such cases a homonymous hemianopsia of the opposite side results.

A direct examination of the eyegrounds with an ophthalmoscope shows *primary optic atrophy* resulting from pressure of the tumor on the optic nerves. This type of atrophy is characterized by pallor of the optic nerve head. That structure sometimes becomes pearly white and all traces of the normal pink color are lost. The edges of the disc are very sharply defined and the vessels become somewhat smaller in caliber. These patients do not have a "choked disc" with *secondary optic atrophy* as evidence of increased intracranial pressure unless a block in the ventricular system occurs. This is a rare complication. Examination on admission showed some degree of primary optic atrophy in 82 cases, early choked disc in 4 cases, and normal fundi in 2 cases. (The cases with choked disc were verified at operation.) It should be emphasized that these symptoms of visual disturbances are very frequent, early and severe with chromophobe adenomas of the pituitary, but are relatively uncommon with acidophilic adenomas. When they do occur in the latter condition, usually they develop later in the course of the disease. They are, of course, not found in association with the small basophilic adenomas.

All these symptoms are slow in onset, as a rule. This is shown by the fact that the duration of symptoms in the cases studied averaged 2 5/12 years before the patient sought medical treatment. The shortest history of symptoms was thirty-six hours and the longest was twenty-eight years.

In the reports in the literature, more and

more patients are being given a therapeutic trial by irradiation before operation. A certain percentage of the patients show a good response, another group a fair response, and a third group no response. This latter group is losing valuable time in delaying operation, since surgical removal is the only means of relieving their symptoms. It was brought out by Towne[18] that those patients not responding to irradiation usually have cystic tumors which may be amenable to surgery. He believed that 20 per cent of all chromophobe adenomas are cystic. Dyke and Gross[7] stated that continued improvement can be expected in a definite percentage of non-cystic tumors if irradiation is given persistently. However, it was felt that cystic tumors did not respond well to this form of treatment. Table III summarizes the results of our study of cystic tumors. Although some of the patients showed a response to irradiation, the improvement was slight. Eight of the tumors were of the diffuse type which showed a less satisfactory response, whether cystic or not (Table IV). Even though the roentgen treatment may hold the growth of the tumor cells in check, it is difficult to see how it can accomplish the absorption of the fluid once it has formed. Few studies have been carried out so far to determine which of the non-cystic tumors do not respond to irradiation and what the reason for this radioresistance may be. For this reason the present series has been especially studied to determine so far as possible the relative benefits derived from operation and from irradiation. Furthermore, the reasons for the variations have been sought both in the clinical and in the histological material.

Eighty-one patients were treated surgically, a total of 93 operations being performed. Of these, there were 14 operations by the transphenoidal route (the earliest cases) and 79 by the transfrontal approach. In the 81 patients, 56 had a radical removal and 25 a partial removal (biopsy) of the tumor at the first operation. Eleven of the 81 cases (13.7 per cent) were cystic. Twelve of the tumors required a second operation, of which 9 had been removed radically and 3 had partial removal only at the first operation. Three of these 12 had been cystic at the first operation.

The number of patients receiving irradiation either before or after operation totalled 42; this included 18 of the 25 who had only a partial removal and 24 of the 56 who had a radical removal at operation. Of the 12 patients requiring a second operation, 5 had received irradiation between the first and second operation and 7 had not.

Sixty of the 81 patients surgically treated are now living (January 1, 1936). A fairly accurate estimate of their present condition has been obtained from personal reports from the patients (as well as a note from their physicians in most instances). Five patients have not been followed satisfactorily. Sixteen of the 81 are dead: 5 were postoperative deaths; 7 died of a recurrence of the tumor, from two months to eight years after operation (none of these had undergone a second operation); 4 died of causes unrelated to the pituitary tumor.

The measure of clinical improvement in chromophobe adenomas is a most difficult one, particularly since so much of it is on a subjective basis. However, one has recourse to visual field changes which, to a large extent, parallel increase and decrease in the size of the tumor, provided the optic tracts are not already destroyed. This is the best objective means now available by which to measure improvement. On the reports received in the follow-up study, the 60 living cases were grouped into four classes, the condition being recorded as of January 1, 1936. The group marked *excellent* indicate those who are leading a perfectly normal active life; the group marked *poor* are those who are totally incapacitated by their illness. The following shows the present condition of the patients with verified tumors in the series, considered as a whole without regard to method of treatment:

Excellent	18 cases
Good	31 cases
Fair	9 cases
Poor	3 cases

As measured by changes in the eye fields, as well as those of visual acuity, it was found in the entire group of patients in whom sufficient follow-up data were available for study,* that 33 cases had operation without any irradiation and 42 cases had operation plus irradiation. Of this latter group only 4 had received an adequate therapeutic test by irradiation before operation; 2 were improved and 2 were held stationary up to operation. Comparing the visual changes in the 33 patients who received operation alone with the 42 patients who received operation plus irradiation, it was found that there was essentially no difference so far as the degree of improvement was concerned. However, the average duration of the period of improvement was prolonged for one year more in the patients receiving irradiation (Table 1).

TABLE I

CHROMOPHOBE ADENOMAS OF PITUITARY
IMPROVEMENT AFTER TREATMENT

	Operation Only	Operation Plus Irradiation
Number of cases	33	42
Average improvement visual acuity*	2/10	2/10
Average improvement visual fields	24%	29%
Duration of visual improvement	3.0 yr.	4.0 yr.
Incomplete follow-up	6 cases	

* Percentage in comparison to condition on admission, not to normal.

Of the 33 patients receiving only surgical treatment, 25 showed improvement of vision after operation and 8 showed no such improvement. In a further analysis of data from the 42 patients receiving operation plus irradiation, to determine whether they were benefited most by operation or by irradiation or essentially equally by both, it was found that 6 were improved by operation (in 3 of these patients, the tumors were cystic); 7 were most improved by irradiation, and 29 were improved following both types of treatment.

A similar analysis was carried out on the 7 cases (1 later verified) who received irradiation alone. These data are given later in this paper.

* One patient recently operated upon is not included because the interval is too short for evaluation of results.

TECHNIQUE OF ROENTGEN THERAPY USED IN THE SERIES

All the roentgen treatments in the present series of patients were given with a 200 kv. mechanically rectified machine. A maximum of 185 kv. with a 4 ma. current was used. This was filtered through 0.5 mm. of rolled copper plus 1 mm. of aluminum. The output of the machine under these conditions was about 9.5 roentgens per minute, with an effective wave length of 0.156 Ångström units. Calibration and wave length determinations were made in air with a Duane ionization chamber, according to the Duane technique. Recently the measurements have been made with a commercial ionization chamber. The maximum suberythema dose with these factors was about 700 r, measured in air, the target distance used having been 48 cm. in most of the cases.

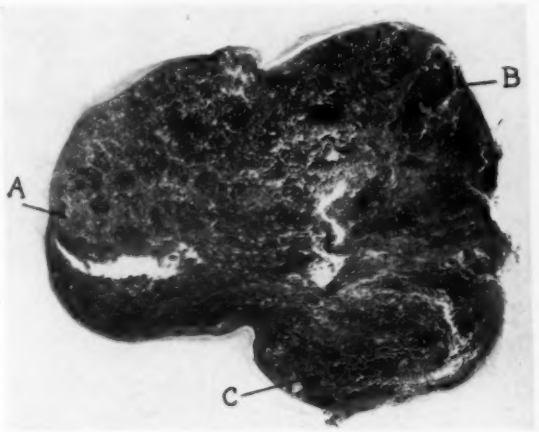


FIG. 1. A section through an entire chromophobe adenoma of the pituitary is photomicrographed at a magnification of 2 diameters. It is well encapsulated. The tissue is uniform in appearance. This photomicrograph should be compared with Figure 8, which shows the relationships of this tumor to surrounding structures. Points *A*, *B*, and *C* are shown at higher magnification in Figure 2.

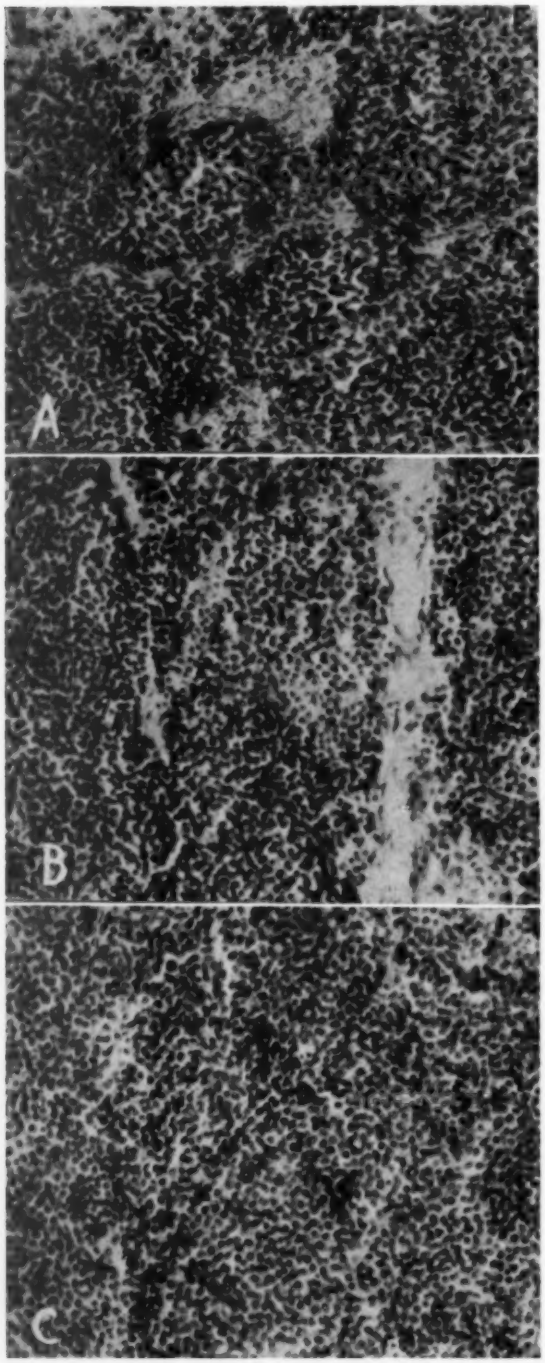


FIG. 2. Photomicrographs *A*, *B*, and *C* show at magnifications of 165 diameters the fields indicated by the corresponding letters in Figure 1. Note that the cells are arranged in the "diffuse" pattern in each instance. There is close similarity of cell patterns in these three fields. The differences in cellular arrangement between this tumor and that shown in Figures 3 and 4 and the constancy of these variations in widely separated fields is striking.

Until 1933, all patients with chromophobe adenoma of the pituitary entering this clinic were treated by surgery.

The postoperative irradiation given to these patients consisted of a series of four treatments of 300 r each, given on successive days to alternate temporal areas. This series of treatments was repeated at the end of six weeks or whenever the subjective and objective findings justified further irradiation, as determined by physical examination and visual fields.

If there has been neither subjective nor objective improvement at the end of three months, it is usually useless to give any more roentgen therapy (although one patient in our series went fully five months after his initial roentgen treatment before any appreciable improvement occurred). In the radioresistant group of tumors, surgery should be performed after four to six weeks without further procrastination. It must be done sooner if vision is becoming progressively worse.

With the advent of higher voltage apparatus, heavier filters, and greater accuracy in measurement of dosage, we have been able, since the analysis of these cases, to carry out more intensive irradiation. At the present time we are using a 200 kv. constant potential machine with the following factors: 18 ma. current, filters of 2 mm. of copper plus 1 mm. aluminum, 50 cm. distance and a 5 cm. portal. The output of this machine with these factors is 32 r per minute with an effective wave length of 0.112 Ångström units. The maximum suberythema dose is about 1,000 r, measured in air.

Our routine technique at present is to administer nine treatments of 300 r each on successive days to successive portals, using each temporal area and the forehead. This gives a total of 2,700 r in the entire series. At the end of two months this is repeated. During the two-month interval the visual fields should be checked every two to four weeks, for this is the most accurate objective criterion for determining the response of the tumor. The subsequent roentgen therapy is determined by the presence

or absence of symptoms such as headache and visual disturbances, and by the appearance of the visual fields. In our experience, there may be prompt relief of headaches and expansion of the visual fields with a general subjective feeling of well-being before the initial series of treatments has been completed.

Some of the patients complain of further increase in lassitude and lack of energy beginning shortly after the completion of the course of irradiation and lasting for two to four weeks. This can often be benefited by giving anterior pituitary extract (Antuitrin G) intramuscularly, but it usually passes off gradually and the patients again resume a life of normal activity.

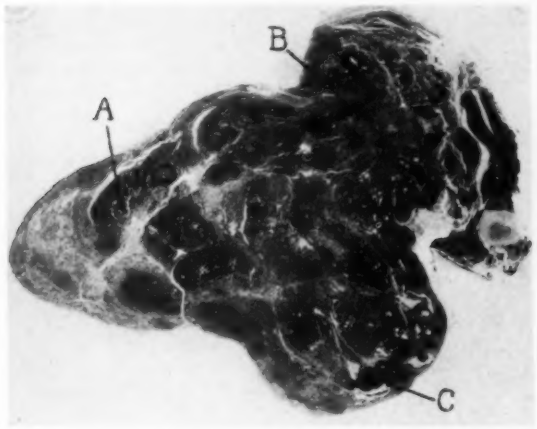


Fig. 3. The photomicrograph shows a cross section of an entire chromophobe adenoma of the pituitary. Note the sharp encapsulation of the growth and the homogeneous appearance of the tissue. Points *A*, *B*, and *C* are illustrated at higher magnification in Figure 4. Magnification, 2 diameters.

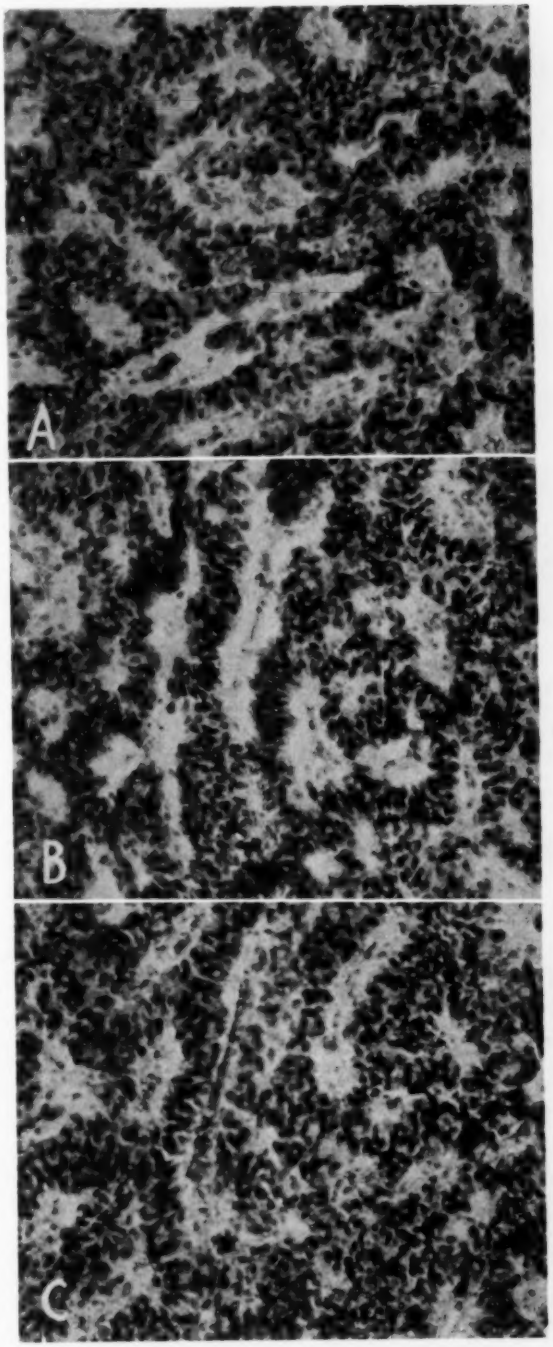


Fig. 4. Points *A*, *B*, and *C* in Figure 3 are here shown at a magnification of 165 diameters. Note the sinusoidal pattern of cellular arrangement in each. There is a distinct similarity of histological arrangement despite the distance separating the fields. It is from evidence such as this that we feel justified in considering biopsy material satisfactory for classification of chromophobe adenomata. It is definitely more reliable for such study in the case of these pituitary tumors than it is in most gliomas.

PATHOLOGIC STUDIES

In this series, considerable attention has been given to the microscopic study of material secured either at the time of operation or at the post-mortem examination. The volume and completeness of the histologic material permit a comprehensive survey of the cellular types as well as the structure and methods of growth of these tumors. The material secured surgically was placed in Zenker's solution with acetic acid in the operating room. When a large

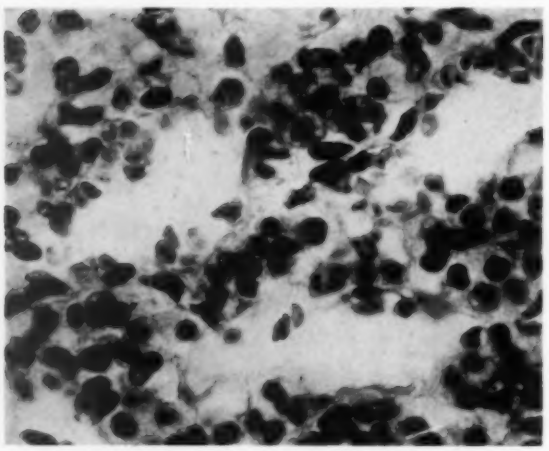


FIG. 5. The photomicrograph shows the appearance of the pars anterior of a normal human pituitary gland. Note the arrangement of cells in cords between capillaries. There are chromophobe and chromophile cells mixed together in the cell cords. Magnification, 900 diameters.

amount of tumor was removed, the rest of the specimen was fixed in formalin and occasionally also in Regaud's fluid. In all instances embedding was in paraffin and sections were stained with eosin-methylene blue and Mallory's phosphotungstic acid hematoxylin. Sections stained with ethyl violet-orange G were available in several instances. In searching for chromophile cells, much reliance was placed on material fixed in formalin and stained with Mallory's aniline blue applied as in staining connective tissue with the exception that 1 per cent acid fuchsin replaced the 0.5 per cent solution of that stain usually employed in the technique. This method can be recommended highly in studies on the pituitary gland and its tumors.

We were particularly concerned as to whether such material really gives a representative sample of each entire tumor or whether the variations in different portions are sufficiently great to invalidate conclusions based only on surgical specimens. In order to study this question, two tumors of large size were chosen from the autopsy material. Entire cross sections of these two tumors were embedded in celloidin, and sections cut so that the arrangement and cellular types could be compared. The tumors chosen were of different histologic types. Comparisons were made between individual fields selected at as great a distance from one another as possible. In addition, each section was examined in consecutive fields in all portions. The constancy of the histologic type was striking. Not only was the cell type the same but the same arrangement of the cells was found throughout a given specimen. Furthermore the variations from tumor to tumor were found to be maintained when the superior portion of one was compared with the superior portion of another and so on. Figures

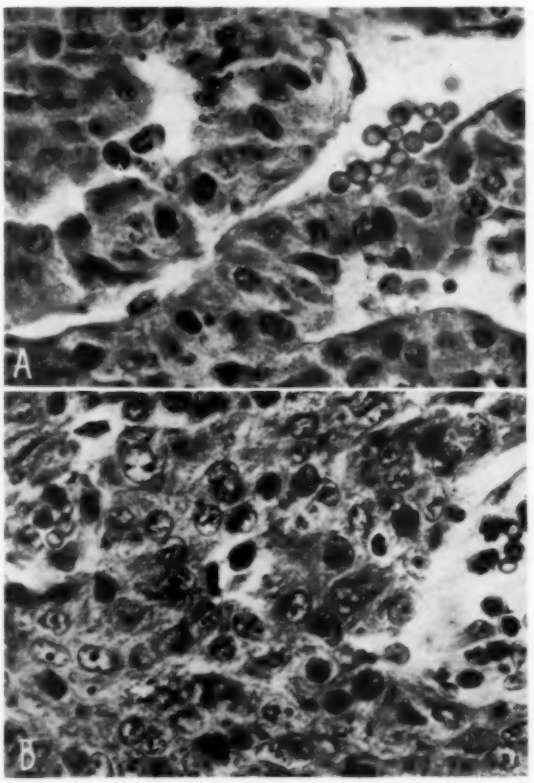


FIG. 6. *A* is a photomicrograph of a chromophobe adenoma of sinusoidal type. The chromophobe cells are arranged in cords which are separated from one another by capillaries. Note the similarity of arrangement between this tumor and the normal pituitary structure (Fig. 5). The tumor contains no chromophile cells. *B* shows a chromophobe adenoma of diffuse type. The cells are arranged in sheets and masses without any particular relation to blood vessels. All suggestion of the structure of the normal pituitary is lost. Magnification, 900 diameters.

1 and 3 show photographs of two of the sections through entire tumors. Figures 2 and 4 illustrate the appearance of individual fields chosen from widely separated points in each tumor. In view of such find-

Table II

CHROMOPHOBE ADENOMAS OF PITUITARY
INCIDENCE OF HISTOLOGIC TYPES

Total number of cases studied microscopically	81
Sinusoidal type	30(37%)
Diffuse type	46(57%)
Unclassified	5(6%)

ings, we felt justified in regarding well-preserved operative specimens as adequate for classification of the chromophobe tumors. However, we have not so considered minute fragments, especially when mixed with much blood clot or when altered by the action of the electrocautery. The cases from which such specimens were obtained are listed as unclassified in Table II.

Study of this material indicates that chromophobe tumors of the pituitary can be divided into two groups, the sinusoidal type and the diffuse type. The percentage of each type is shown in Table II. We have also encountered in our material 3 specimens which must be considered malignant chromophobe adenomas. The cases are not included in the present series and will form the basis of a separate report.

Fig. 7. Roentgenogram of a patient with a large chromophobe adenoma, taken shortly before death. Note the enormously enlarged sella. The specimen obtained at autopsy is shown in Figure 8.

Fig. 8. A photograph of the gross specimen of a large chromophobe adenoma of the pituitary and adjacent structures. The specimen has been cut in the mid-sagittal plane. Note the encapsulated character of the growth. The nasopharynx is free from tumor. The microscopic appearance of this specimen is shown in Figures 1 and 2, and the roentgenogram shortly before death in Figure 7.

Sinusoidal Type. In this group, the tumor cells are found in layers, usually two or three cells deep, along capillaries and connective tissue fibers which are arranged somewhat like those seen in the anterior lobe of the normal pituitary (Fig. 6*A*). Low power inspection of the section, therefore, shows a pattern of delicate blood sinusoids and collagen fibers forming a network which supports the tumor cells. The individual tumor cells in general have the morphological characteristics of those of the chromophobe cells of the normal pars anterior. In some few instances, they assume a spindle shape. The nuclei are of medium size and are provided with a dense chromatin network. Mitotic figures are rarely found. The cytoplasm takes a pale

stain and its limits are demonstrable only with difficulty in many instances. With high power magnification, there are numerous fine cytoplasmic granules which are nearly neutral in staining reaction, but the strongly stained, coarse granules of the chromophile cells are not present. In places these tumors may give the appearance of a papillary manner of growth. They consist of a central capillary blood vessel surrounded by chromophobe cells. Such groups are separated from one another by partially desquamated or entirely necrotic material. The papillary appearance, therefore, seems to result when the blood supply is adequate to nourish only the cells immediately adjacent to the vessels of the tumor. An arrangement similar to this may also result from artefact when the material is removed forcibly from a large tumor with considerable hemorrhage. Then the blood dissects through the masses of tumor cells while those adjacent to vessels adhere to them and to the accompanying collagen fibers. The papillary arrangement must therefore be considered a secondary phenomenon. In summary, tumors of the sinusoidal type of chromophobe adenoma are composed of cords of chromophobe cells arranged along sinusoids in a relationship which resembles in many respects the pattern of the normal pars anterior.

Diffuse Type. We have placed in this second group chromophobe adenomas in which the tumor cells are arranged in sheets and masses. There is still a vascular stroma, but evidence of sinusoidal arrangement is lost (Fig. 6*B*). The blood vessels, usually of capillary structure but often larger than those in sinusoidal tumors, are placed irregularly through the closely packed cells. The tumor cells retain for the most part the histologic features of the chromophobe elements of the normal pituitary. In the diffuse type, there is somewhat more variation in individual cells, however, than in the sinusoidal type. More often, spindle-shaped cells are seen, and occasionally there is considerable variation in size. These differences in type of cell are slight, on the whole, and are usually seen in a few cells scattered among many cells with the appearance of normal chromophobe cells. There are no differences in individual cells in the diffuse and sinusoidal types which permit the classification of the tumors on that basis. The differentiation is made entirely on cell grouping and on the relation of tumor cells to their stroma.

General Behavior of Chromophobe Adenomas of Sinusoidal and Diffuse Types. The natural history, so to speak, of the two varieties of chromophobe adenoma just described is entirely similar. The neoplasms are derived from a type of cell which is glandular in nature. Such cells, regardless of site, are specialized for secretory activity, and are dependent for growth and support upon a stroma. This varies a good deal with the tissue concerned, but consists essentially of some sort of connective tissue and blood vessels. When tumors take their origin in glandular cells, a stroma is still necessary, but its relation to such cells, its quantity and occasionally its character are altered. Its presence, however, is essential for the growth of the neoplasm. The chromophobe cells are glandular cells, and are supported normally by delicate collagen fibers with capillaries in sinusoidal arrangement. Thus it becomes apparent that our two groups differ from one another largely in their relation to a supporting and nutritive tissue.

A special feature of interest in the chromophobe adenomas is cyst formation. Its clinical significance is discussed above. A study of the 11 cases in our group of 81 in which the surgeon made the operative note that the tumor was cystic indicates that they do not all fall into any special histological group. Three are of the sinusoidal types, 8 of the diffuse. These numbers are too small for any definite statistical conclusions (Table III). To us the cysts represent the result of degenerative changes, the pathogenesis of which remains unknown. The fluid is not large in amount. One is led to speculate whether it may accumulate because of changes in osmotic pressure oc-

casioned by tissue breakdown. We have not had an opportunity to study a cystic chromophobe adenoma at autopsy, and therefore cannot state with certainty the character of the cyst walls and their general relationships.

Study of entire cross sections of adenomas (Figs. 1 and 3) show a number of interesting features of their growth and development. The homogeneity of the histologic arrangement of tumor cells has been discussed above. These sections show also that the neoplasms are surrounded by a dense connective tissue capsule. The growth is progressive at the center and causes its effect on adjacent structures through pressure. The Gasserian ganglion is displaced, but there is no extension of tumor into its substance. An additional finding of some interest is the demonstration of remnants of the anterior lobe of the pituitary (Fig. 9). This is seen at the periphery. It has been compressed by the tumor and shows considerable atrophy. The cords of chromophobe, acidophile, and basophile cells are thinned, but the cells retain their normal relationships and proportions to one another. The connective tissue appears definitely increased. One is struck by the abrupt transition from normal gland to tumor. These residual portions of anterior lobe tissue explain why the function of the anterior lobe is not entirely suppressed though insufficient for the needs of the body. The possible presence of such bits of surviving pars anterior in a chromophobe adenoma should be borne in mind when deciding from a small fragment of tissue removed at operation whether a given tumor is a chromophobe adenoma or one of mixed chromophobe and chromophile cells.

We can make little contribution to the knowledge of the histologically detectable

Table III

CYSTIC CHROMOPHOBE ADENOMAS OF PITUITARY RESPONSE TO IRRADIATION

	Sinusoidal Type	Diffuse Type	Total
Number of cases receiving irradiation	2	4	6
No response to irradiation	1	3	4
1–15% improvement	1	1	2
Number of cases receiving no irradiation			5
Total cystic tumors in series			11

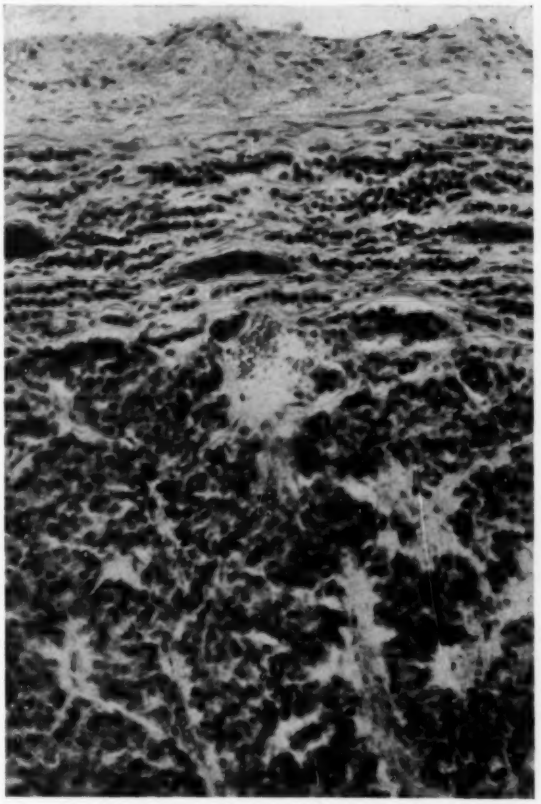


Fig. 9. Photomicrograph of the edge of an adenoma of the pituitary to show the presence of a portion of pars anterior near the capsule. The cords of glandular cells contain chromophobe and chromophile cells. The division between it and the tumor is distinct. The pars anterior tissue shows the effects of pressure atrophy in elongation and thinning of cords and in increase in connective tissue. The presence of such tissue in chromophobe adenomas explains the preservation of partial function of the pars anterior of the pituitary early in the course of chromophobe adenomas. It also suggests that their atrophy by pressure of the growing neoplasm is the mechanism for their final destruction rather than invasion by tumor cells. Since fragments of normal tissue appear to be able to carry on a certain amount of the function of the pars anterior, the patients are often troubled by visual disturbances before the symptoms of hypopituitarism develop.

effect of roentgen rays on the chromophobe adenomata. The opportunity to study at autopsy one of these tumors a few hours or days after irradiation has not been afforded us. Percival Bailey[1] states that extensive necrosis and edema are the principal changes at this stage. Extensive areas of necrosis are seen in chromophobe adenomas, perhaps most often in heavily irradi-

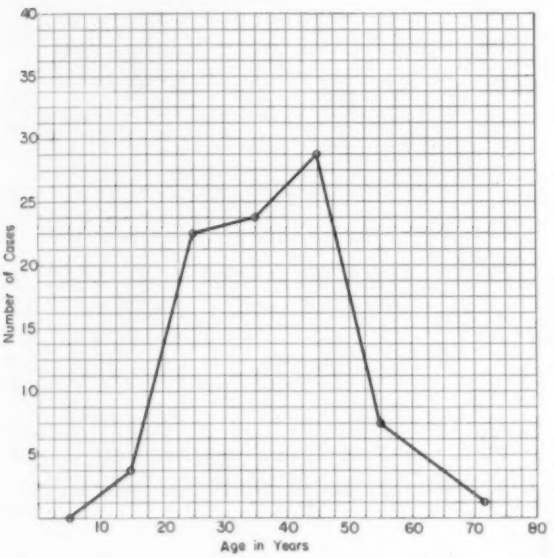


CHART 1. Chromophobe adenomas of pituitary; age incidence.

ated tumors. In such instances, the areas of necrosis after a time tend to be repaired by ingrowth of collagenous tissue and capillaries. This results in a cicatrix, more or less vascular. If it is permissible to judge from experience with normal tissues, the degree of vascularity is an indication of the age of the cicatrix, the most vascular being most recently formed. In relating these findings with the effects of roentgen rays, one hesitates to use a cicatrix as proof of an antecedent process unless the steps leading to its development are still detectable. Comparison of specimens removed before and after irradiation has shown no histological differences which we felt justified in attributing to its action alone. So far as we can tell from our material, the shrinkage of the tumor recognized clinically and roentgenologically results from necrosis and its repair rather than from any change in type of tumor cells. This necrosis probably results from effects on blood vessels as well as from direct necrosis of tumor cells in response to roentgen therapy. Additional evidence for this is seen in the finding that the more vascular tumors (sinusoidal type) are benefited more by this treatment than are those of diffuse type.

Any study intending to correlate the effects of irradiation with histologic changes, especially in regard to dosage, must include examination of the entire tumor, particularly its older portions. There is constant cellular growth in these tumors. The edges are the portions most accessible for surgical removal, yet these may not have been irradiated at all if roentgen therapy has been discontinued some time before operation. At any rate, the edges of a tumor could not be expected to show the full effect of long-continued irradiation. For this reason we feel that an adequate understanding of the effects of irradiation on these tumors must await the collection of many specimens studied in whole section, as we have been able to do thus far in only 2 instances.

COMMENT

This study has made available data regarding patients with chromophobe adenomas who had received treatment with surgery only, roentgen therapy only, and a combination of the two. The issues are clear when one form of treatment was used. When both were employed, regardless of the order, it is most difficult to assign a given result to one or to the other or to determine the contribution of each. For instance a decompression of the sella turcica with removal of a fragment of tumor, without roentgen therapy, can produce a striking clinical improvement for a short period of time. It therefore makes one cautious in assigning temporary improvement to roentgen therapy when it follows a biopsy. On the other hand, our series includes equally striking improvement with roentgen therapy alone.

In the present series of cases there ap-

peared to be no striking difference between the degree of immediate improvement produced by a radical extirpation and by a partial removal of the tumor. The reason for this lies in the fact that decompression of the sella is the principal factor in the immediate improvement but not necessarily the essential one in the eventual result. Immediate and rapid improvement often follows surgical procedures of either type as measured by the decrease in size of the defects in the visual fields. This can be seen in some patients whose operations were carried out under local anesthesia even before they leave the operating room. The decrease in visual defects continues up to two or three weeks while the edema of the optic nerves is subsiding. After that, vision may improve still further, but more slowly. It was usually after this interval of two to three weeks that postoperative irradiation was given to the 42 patients who received it. Therefore, in analyzing the results in these cases, one month was allowed after operation to determine the relative degree of improvement due to surgery alone. The subsequent relative degree of improvement due to irradiation was then taken as that which followed about one week after irradiation was instituted, plus one month after the operation. After this allowance for the improvement due to operation had been made, the maximum further improvement attributed to postoperative irradiation was calculated as 50 per cent. Certainly this is not fully accurate, but in such a study one can hardly formulate absolute values.

The best data for use in the determination of clinical improvement in these cases are carefully repeated visual field examinations made in the 88 patients; the 42 case studies of patients who had operation plus irradiation had 397 sets of visual field examinations. In comparing the ultimate visual improvement (in both visual acuity and peripheral field vision) in the patients receiving irradiation and those who did not, it was found that there was no noticeable difference in the degree of improvement in the two groups, but the duration of sustained improvement was approximately one year longer in the group receiving irradiation (four as compared to three years) (Table I).

Table IV shows that of the sinusoidal and diffuse types a somewhat better response to irradiation occurred in the sinusoidal tumors with 30 to 50 per cent improvement in 9 of the 16 cases treated by roentgen therapy after operation (56.2 per cent). This same group tends to show either a minimal or maximal response to irradiation. The cases with the diffuse type of neoplasm show a fairly equal distribution in their response to irradiation, but in a smaller group there is an improvement of 30 to 50 per cent (6 of the 25 cases treated by roentgen therapy after operation). The sinusoidal type more nearly resembles the normal and yet, in this series of cases, seems to be the type most responsive to irradiation. This may bear some relation to the greater vascularity of the sinusoidal type. Table III gives the results of irradiation in the cystic tumors of this series.

TABLE IV

CHROMOPHOBE ADENOMAS OF PITUITARY: RESULTS OF IRRADIATION AFTER OPERATION

Further Improvement in Visual Fields* Due to Irradiation	Sinusoidal Type	Diffuse Type	Unclassified
No response	3	7	
1–15%	4	5	
15–30%	0	7	
30–50%	9	6	1

* Percentage in comparison to condition on admission, not to normal.

A review of the 7 patients who have been treated by irradiation alone since 1933 gives a very favorable outlook to this form of therapy. These 7 cases were followed closely from three months to three and one-half years with careful checks on their visual fields. Subsequent irradiation was given as indicated by this index. The 5 patients treated for at least a year or more had received from 15 to 30 treatments (4 to 6

series) during their period of observation. All cases have shown a maintained improvement except one, who subsequently received surgical treatment. The tumor was found to be a typical chromophobe adenoma of diffuse type. Since irradiation was the only form of treatment carried out in this group, we can estimate the maximum improvement as 100 per cent, which indicated a return to full normal vision, as tabulated:

Patient	*Improvement*
M.C.	90%
H.O.	90%
I.K.	50%
E.G.	25%—subsequent operation
C.W.	25%
J.V.	95%*
B.W.	15%

In patients who have a radiosensitive tumor the future course of irradiation should be determined by the general symptomatology, such as headaches and visual disturbances with changes in the visual fields. These patients should be seen for check-up examination, including visual field charting, every two months during the first year and as frequently thereafter as is indicated by these objective findings. This should be done even though subjective symptoms have not returned. In the event that the patient begins to fail after a previous improvement by roentgen therapy, surgical removal of the tumor is indicated.

This series of 81 verified cases is relatively large as far as this type of tumor is concerned. Further data are required to reach conclusions on many points. The study of this problem can be illuminated by biopsy or post-mortem studies of the tumors removed from patients who have had adequate irradiation previously and who have been followed carefully through their series of roentgen treatments by visual field examinations.

SUMMARY

Eighty-one verified cases of chromophobe adenoma of the pituitary were analyzed from the standpoint of their clinical improvement following surgical intervention alone and after operation plus irradiation. A study of the pathologic features of these cases was made to determine variations in their cellular structure and arrangement. An attempt was then made to correlate the degree of improvement following irradiation with structural arrangement in the tumor. In addition seven patients receiving roentgen therapy only were studied.

The technique of irradiation is fully outlined.

The tumors were found to be made up of two histologic types—sinusoidal, in which the relations between cells and blood vessels of the normal pars anterior were preserved, and diffuse, in which the tumor cells grew in irregular sheets and masses. Eleven of the 81 cases (13.7 per cent) were cystic. Their response to irradiation was less satisfactory than that of the remainder of the series.

In this series of cases it appears that the sinusoidal type (the most differentiated type of tumor) is more radiosensitive clinically and this sensitivity is probably augmented if the tumor is avascular and solid.

The seven patients with clinically typical chromophobe adenomas who received only roentgen therapy showed responses somewhat more satisfactory than those of the remainder of the series.

CONCLUSION

In our opinion chromophobe adenomas, unless there be urgent need for saving vision, should have a trial with radiation treatment before recourse is had to surgery.

We wish to express our appreciation to Dr. Harvey Cushing for his permission to use the cases of chromophobe adenoma of the pituitary which were on his service at this hospital from January, 1928 to September 1, 1932.

* June 1, 1938. This patient now has no defect in visual fields and is entirely free from symptoms.

REFERENCES

1. BAILEY, P. Results of roentgen therapy on brain tumors. AM. J. ROENTGENOL. & RAD. THERAPY, 1925, *13*, 48–53.
2. BÉCLÈRE, A. Technique, résultats, indications et contre-indications de la roentgenthérapie des

tumeurs hypophysaires. *Rev. neurol.*, 1922, *38*, 808–816.

3. Benda, C. Beiträge zur normalen und pathologischen Histologie der menschlichen Hypophysis cerebri. *Berl. klin. Wchnschr.*, 1900, *37*, 1025.
4. Cairns, H. Prognosis of pituitary tumours. *Lancet*, 1935, *2*, 1310; 1363.
5. Cushing, H. The Pituitary Body and Its Disorders. J. B. Lippincott Co., Philadelphia, 1912.
6. Cushing, H. "Dyspituitarism": twenty years later, with special consideration of pituitary adenomas. *Arch. Int. Med.*, 1933, *51*, 487–557.
7. Dyke, C. G., and Gross, S. W. Roentgenotherapy of pituitary tumors. *Bull. Neurol. Inst. New York*, 1931, *1*, 211–228.
8. Elsberg, C. A. Present status of surgery of tumors on the brain. *Am. J. Surg.*, 1936, *31*, 193–195.
9. Frazier, C. H. Indications for surgical treatment of primary pituitary lesions with description of approved methods of approach. *Pennsylvania M. J.*, 1931, *35*, 88–91.
10. Frik, K. Zur Röntgenbehandlung der Hypophysentumoren. *Strahlentherapie*, 1931, *42*, 437–452.
11. Gramegna, A. Un cas d'acromégalie traité par la radiothérapie. *Rev. neurol.*, 1909, *17*, 15–17.
12. Harris, W., and Selinsky, H. Radiotherapy of pituitary tumors. *Radiology*, 1932, *18*, 777–782.
13. Heinismann, J. I., and Czerny, L. I. Die Röntgentherapie der Hypophysentumoren. *Strahlentherapie*, 1926, *24*, 331–335.
14. Heuer, G. J. Surgical approach and treatment of tumors and other lesions about the optic chiasm. *Surg., Gynec. & Obst.*, 1931, *53*, 489–518.
15. Meredith, J. M. Selection of pituitary cases for surgery. *Ann. Surg.*, 1935, *101*, 228–236.
16. Pfahler, G. E., and Spackman, E. W. Roentgen therapy in pituitary tumors. *Am. J. Ophth.*, 1931, *14*, 796–807.
17. Rand, C. W., and Taylor, R. G. Irradiation in treatment of tumors of pituitary gland. *Arch. Surg.*, 1935, *30*, 103–150.
18. Towne, E. B. Treatment of pituitary tumors. Rôle of röntgen-ray and of surgery therein. *Ann. Surg.*, 1930, *91*, 29–36.

THE PLACE OF IRRADIATION IN ACROMEGALY

REPORT OF FIFTY-THREE CASES*

By W. W. VAUGHAN, M.D.
DURHAM, NORTH CAROLINA

THERE is probably no other lesion treated with roentgen rays that is marked by more dramatic results than those obtained in radiosensitive pituitary adenomata. The radiologist has no other patient who expresses more profound appreciation and gratitude for his services than the one with a pituitary adenoma who is restored to an active and useful life, after having suffered from the impaired vision and headache so often a result of the disease.

In the preceding paper, the authors have pointed out the results obtained in 88 cases of chromophobe adenomata of the pituitary gland.† The purpose of this phase of the discussion is to tabulate the present status, as far as possible, in 53 patients with acromegaly who have been studied since January 1, 1928. This discussion will include the signs, symptoms, pathology and prognosis of acromegaly as observed in this group of cases, and the results following irradiation of the pituitary gland.

HISTORICAL

In 1909 Gramegna[12] reported the first instance of a pituitary tumor treated by roentgen rays. This patient was a woman, aged forty-five, who presented the signs and symptoms of advanced acromegaly. He used only one portal, that being through the mouth, and gave eight treatments, two each week. Eight to 9 Benoist units were given at each treatment. Rapid subjective and objective improvement was observed, but this was only temporary. Seven months later the original symptoms recurred and another series of roentgen treatments was given, with less marked benefit. Although the improvement was of short duration, Gramegna believed the response was sufficient to justify the use of roentgen therapy in all pituitary tumors before resorting to surgery.

The following year Béclère[2] reported a case of a pituitary tumor in a sixteen-year-old girl who showed gigantism. She complained of excruciating headaches. The sella turcica was markedly enlarged. Vision was impaired. The patient responded well to roentgen therapy and was reported in excellent condition thirteen years later. This was the first reported case of an apparent cure by irradiation. Béclère used both temporal fields for portals.

Gramegna did not state the factors used in treating his case, but it is obvious that with the equipment available at that time, not more than a fraction of an erythema dose could have been given to the pituitary gland without producing irreparable damage in the superficial tissues. The improvement in equipment, standardization of dosage, change in technique, and accumulation of knowledge concerning roentgen radiation since Gramegna's original report mark an epoch in roentgen therapy. It is now possible to give more than an erythema dose to the pituitary gland without any untoward results. Likewise, during the same period, along with the improvement in roentgen therapy, surgical treatment of pituitary adenomata has made unparalleled progress. Operative mortality has been reduced to less than 5 per cent. By close cooperation of the radiologist and neurosurgeon the mortality may be further reduced and a better prognosis offered the patient suffering from a pituitary adenoma.

* From the Surgical Clinic and the Department of Roentgenology, Peter Bent Brigham Hospital, Boston, Mass. Read at the Thirty-seventh Annual Meeting, American Roentgen Ray Society, Cleveland, Ohio, Sept. 29–Oct. 2, 1936.

† The third paper in this symposium, that by Merrill C. Sosman on the effect of irradiation on basophile tumors, will be published in a later issue of the Journal.

LITERATURE

Dott, Bailey and Cushing[9] in 1924 reported upon 162 hypophyseal adenomata. Their publication is one of the most thorough and comprehensive discussions of the pathology, symptomatology, physiology, classification and treatment of pituitary tumors. These writers, however, gave no statistics as to their therapeutic results other than the operative mortality. They reported that roentgen therapy had been of definite value in treating pituitary adenomata and advocated a trial of roentgen therapy unless there was imminent danger of loss of vision. If vision was threatened, a decompression of the sella should be done forthwith. They concluded that even where operation was necessary, roentgen therapy should be given later in the hope of retarding further growth of the tumor.

Bailey,[1] in his discussion of the effect of roentgen therapy on brain tumors in 1925, reported a pituitary adenoma that was controlled by irradiation following operation. He also pointed out the danger which may follow roentgen therapy to the brain due to edema.

In 1926 Towne[20] reported 3 cases of acromegaly treated by irradiation. All of these were potentially cured. He thought that all hypophyseal tumors which were radioresistant were cystic.

Heinismann and Czerny[15] reviewed 28 cases reported by Küpferle and Szily, all of which were described as pituitary tumors, but the classification was not given. Thirteen of these responded well to irradiation, 10 were not improved and 1 was made distinctly worse following a series of roentgen treatments. The writers reported 6 cases of acromegaly, all of whom improved after roentgen treatment.

In 1931 Pfahler and Spackman reported 6 cases of pituitary adenomata, and in a subsequent report[17] published in 1935 added 15 more cases. No attempt was made to classify these tumors, but from the signs and symptoms given, 6 may be considered to be in the chromophile group. Three of these responded well to roentgen therapy. These writers advised surgery if there was not considerable evidence of improvement six weeks following the roentgen therapy.

Berven[3] stated that there was immediate symptomatic improvement in the purely acromegalic patients who had no visual disturbance. He thought the improvement was usually permanent. He also stated that in patients other than those with acromegaly who had visual disturbances, the improvement might be expected to last more than eighteen months.

Harris and Selinsky[14] reported 13 cases of pituitary tumors, 5 of which may be considered chromophiles. All of them responded well to irradiation. They considered failure to respond to roentgen therapy a definite indication that the tumor was cystic.

In 1932 Hare and Dyke[13] reported 20 cases, 5 of which were chromophile and the remaining 15 chromophobe adenomata of the pituitary gland. Of their series of patients, 5 were markedly improved. Two of the 5 had chromophile adenomata. The writers compared their results with the surgical results obtained by Cushing and showed that roentgen therapy was slightly less favorable. They believed that there was no difference in the response of the chromophile and chromophobe adenomata to irradiation.

PATHOLOGY

In contrast to the chromophobe adenomata, chromophile tumors that produce acromegaly or gigantism frequently do not attain the size necessary to produce ballooning of the sella turcica. In the present series of 53 cases there were 11, or 20.7 per cent, in which there was no demonstrable enlargement of the sella turcica on the roentgenograms. One patient in this latter group had an exploratory craniotomy at her own insistence and a normal sized pituitary gland was found. On the other hand, these chromophile tumors may grow to an enormous size, completely destroying the sella turcica, and compressing the normal hypophysis to the point of destruction. The

tumor growth usually follows the path of least resistance; it may extend out to either side of the sella turcica, or extend upward through the diaphragma sellae without giving roentgenographic evidence of sellar destruction. Two of the 17 operative cases in the present series were cystic. Calcification is rare; it was not demonstrated in a single case of this series.

The histopathology has been very ably presented by Dott, Bailey, and Cushing.[9] The systemic changes are those of hyperplasia of the connective tissue producing enlargement of practically every organ and constitutent of the body, as described by Cushing and Davidoff.[7]

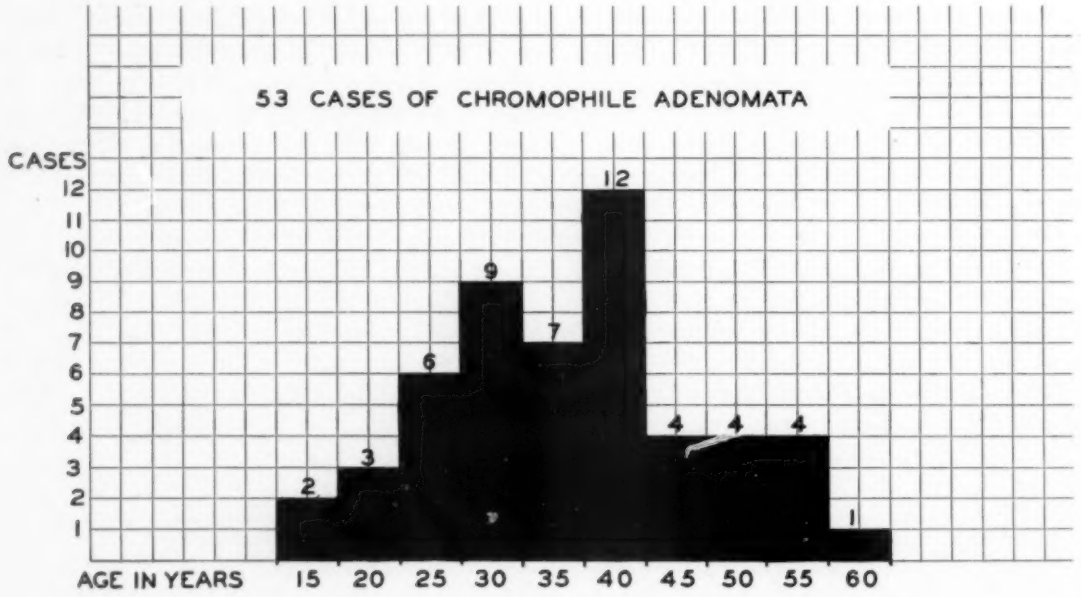


FIG. 1. Age incidence in semidecades of 53 cases of acromegaly. The majority appear between the ages of thirty and forty-five.

INCIDENCE

In Cushing's series of 2,023 verified intracranial tumors, there were 360, or 17.8 per cent, hypophyseal adenomata.[8] The chromophile group constituted 20.3 per cent of these. The fact that only 32 per cent of this present series of 53 cases was operated upon suggests that the chromophile adenomata really constitute about 37 per cent of the pituitary adenomata. This is in accord with the relative percentage of chromophile cells found in the normal pituitary gland by Rasmussen.[19] It also corresponds fairly closely to the percentage distribution recorded in the literature. However, Costello,[5] in his description of subclinical adenomata of the pituitary gland, based on a study of 1,000 autopsies, found that only 7.5 per cent were chromophile adenomata as compared with 52.8 per cent of the chromophobe type.

The age and sex incidence of chromophile adenomata closely simulates that of the chromophobe group. In the present series of 53 cases, there were 29 females and 24 males. The youngest patient was eighteen years, the oldest sixty. The average age for the entire series was thirty-nine years, with the majority occurring during the interval from twenty-five to forty-five years (Fig. 1).

SYMPTOMS AND SIGNS

The chromophobe adenomata present predominantly the symptoms of hypopituitarism such as adiposity and lack of energy accompanied by local pressure effects characterized by visual disturbances and

headaches. The chromophile adenomata, however, are characterized clinically by hyperpituitarism early, and local pressure signs late, if at all. Among the first symptoms are personality changes. The patient becomes irritable, recalcitrant, unappreciative, and minor details become quite annoying. Friends and relatives seem to get on their nerves. Oftentimes the symptoms closely simulate those associated with hyperthyroidism. They develop a voracious appetite, often with a selective taste for some particular type of food such as sweets. One patient of this series stated that she would frequently consume a pound of candy at one sitting. Polydipsia and polyuria are often prominent symptoms. Such patients become nervous and perspire quite freely. Alteration of the sexual function in the male is quite variable; there is often hyperactivity early in the disease with depression and impotency in the later stages. Menstrual irregularities in the female are practically always present. Menorrhagia occurs early in the disease followed by amenorrhea in the late stages. There seems to be some relationship between the size of the sella turcica and the degree of menstrual irregularities. It is not uncommon, however, to find menstrual irregularities in a patient with active acromegaly who has a normal sella turcica. In fact, the case included in this series that had an exploratory craniotomy with negative findings gave amenorrhea as the initial symptom.

Fig. 2. Case 43170. Intracranial extension of chromophile adenoma outlined by ventriculography. Tumor measures 4.6 cm. from the tuberculum sellae and compresses the foramina of Munro.

Fig. 3. Case 43170. Five months later showing a definite decrease in the size of the intracranial tumor following two series of roentgen treatments each totalling about 1,400 r. Decrease was associated with marked clinical improvement but this was not permanent.

As the disease progresses, acromegalic features develop. These are characterized by thick, coarse, and leathery skin, hypertrichosis, enlargement of the hands and feet, prognathism and a generalized hyperplasia of the connective tissue. Headache is a constant symptom, even early in the disease, and oftentimes precedes other complaints by one or more years. Likewise, it is usually the first symptom alleviated by roentgen therapy.

Visual disturbances are not so common as in the chromophobe adenomata, there being only 44.2 per cent of this series who entered that in their chief complaint. The disease is usually far advanced before the optic chiasm is compressed. The first eye symptom, however, may be sudden blind-

ness. This is occasionally due to hemorrhage either into or around the tumor. The most frequent visual finding is contraction of the fields of vision, beginning in the upper outer quadrant. Frequent and accurate visual field determinations offer the best criteria for evaluating progression or regression in the size of the adenoma.

FIG. 4. Florence E. At the beginning of acromegaly five years before admission. Disease was apparently aggravated following the birth of her second child.

If the tumor is not treated, it may occasionally undergo spontaneous regression with abatement of headache and some improvement in the texture of the skin, as well as general symptomatic improvement. This makes it difficult to evaluate the benefit derived from any form of therapy. The usual course of the disease, however, is slowly but steadily down hill. The patient becomes markedly deformed by overgrowth of osseous tissue. There is extensive hypertrophic arthritis with fixation of the spine. The final stage of the disease is one of marked debility and generalized weakness.

LABORATORY FINDINGS

The clinical course of the disease can, in great measure, be determined by accurate laboratory studies. The blood sugar tolerance curve is elevated and prolonged, indicating a low sugar tolerance, and the patient may have sugar in the urine. The basal metabolic rate is elevated early in the disease, but is usually subnormal in the late stages. In 1931 von Margitay-Becht and Miklós[16] demonstrated the presence of prolan in the urine in patients with active acromegaly. Recently Portmann[18] and his coworkers have found that the amount of prolan in the urine may be used as an index of the activity of a chromophile adenoma. Calcium excretion is usually elevated, but some writers contend that the calcium output does not fluctuate according to the activity of a chrompohile adenoma, but is dependent in part on the calcium intake.[6]

PROGNOSIS

It is difficult to give an accurate prognosis in acromegaly. That some acromegalics live a long and useful life is well known, but from the data accumulated in this study, it is apparent that the majority of patients suffering from acromegaly do not have a good outlook. During the eight-year interval from which these cases were selected 17 (39.5 per cent) of those with recent follow-up studies are dead. Of the remaining 26 cases, 3 may be considered without complaints. Seventeen cases are classified as good, but each of these has one or more complaints, though physically able to gain a livelihood. The remaining 6 are invalids. Diabetes mellitus, apparently pituitary in origin, is a common complication. It occurred in 5 (11.6 per cent). This is quite refractive to insulin therapy and frequently offers a difficult problem. Cairns[4] states that one can never assure the patient with acromegaly that he will not develop diabetes. Other complications occurring in this group were hyperthyroidism, obstinate

constipation, weakness, and anemia. It is interesting to note that the cause of death in 11 instances (64.7 per cent of the fatal cases) may be attributed directly to intracranial extension of the tumor. This impression has been formulated by signs and symptoms presented by the patients and not by autopsy findings except in 2 cases. Thus we can readily see that a guarded prognosis must be given in every case of acromegaly, regardless of the form of treatment.

ROENTGEN THERAPY

The technique used in treating chromophile adenomata of the pituitary gland is the same as that described under the discussion of chromophobe adenomata. In the initial series, nine treatments, 300 r each, are given on successive days through three different portals. The two temporal fields and forehead are used in rotation. In the radiosensitive tumors there is prompt symptomatic relief, as evidenced by loss of headache. The headache may disappear within three hours after the initial treatment. If vision is impaired or visual fields contracted, there is prompt improvement. There is cessation of polydipsia and polyuria and a general feeling of well being. The personality changes are rapid. Later there is an improvement in the general features. This is, of course, limited to the soft tissues and is most obvious about the face. There is an actual decrease in the size of the hands and feet due to decrease of edema. Bony changes are permanent and regression has not been noted.

Should prompt improvement not occur, it suggests that the tumor is radioresistant; however, if vision shows no further impairment, the initial series of treatments should be repeated after two months and further observations for improvement noted. If there is no evidence of remission following the second series of treatments, the tumor may be considered radioresistant.

We believe that even though there is marked improvement following the first series of roentgen treatments, the series should be repeated following a two- or three-month interval. The subsequent radiotherapy is determined by the progress and status of the patient. The return of subjective symptoms justifies further irradiation. The suspicion of activity of the chromophile adenoma can be verified by the laboratory tests previously enumerated i.e., prolan determinations, glucose tolerance tests, calcium excretion, change in the basal metabolic rate, and regression of the fields of vision.

Fig. 5. Photograph of patient five years after Figure 4. Moderately advanced acromegaly. Collateral signs and symptoms quite marked, especially menorrhagia, polyphagia, polydipsia, headaches, weakness, lassitude and mental irritability. No visual failure. Basal metabolic rate—4 per cent. Patient has been symptom-free and in excellent condition, with roentgen treatments only, since February, 1932.

The total dosage, 2,700 r, in a series of treatments will be criticized by many radiotherapists, but this dosage has been arrived at by follow-up observations on

TABLE I

TREATED BY OPERATION ALONE—4 CASES

Number of Cases	Average Duration of Symptoms Before Observation (years)	Present Status	Average Duration of Life Since First Observation (years)
0	0	Excellent	0
1	1	Good	5
0	0	Poor	0
1	8	Dead (25%)	4
2	10	No follow-up	—

patients treated. Even with this dose, there may be a period of lethargy, lowered vitality, and further lowering of the basal metabolic rate. The patient may become quite uncomfortable and apparently quite susceptible to infections and other complications during this interval. Substitution therapy during this period of post-irradiation debility has been of little avail. However, after an interval varying from one to two months there is a gradual return to normal. The patients during this interval of debility are very prone to become discouraged. The radiologist must keep up the patient's spirits by comforting psychotherapy.

MATERIAL AND RESULTS

Fifty-three cases of clear-cut acromegaly are included in this series of cases. Forty-two of these had demonstrable enlargement of the sella turcica. Eleven, or 20.7 per cent, had a normal appearing sella on the roentgenogram. In the latter group of cases the diagnoses were made on the symptoms and physical signs. All of them presented moderate to advanced acromegaly.

TABLE II

TREATED BY OPERATION PLUS IRRADIATION—13 CASES

Number of Cases	Average Duration of Symptoms Before Observation (years)	Present Status	Average Duration of Life Since First Observation (years)
1	5	Excellent	6
5	5.4	Good	8
0	0	Poor	0
6	9	Dead (46%)	6.3
1	12	No follow-up	—

Seventeen patients were operated upon nineteen times without a single operative fatality. Forty-three patients have had recent follow-up studies. The present status of these has been compiled in table form. The patients have been divided into five groups according to the form of treatment they have received. Each table includes the average duration of the disease before the initial observation, present status of the patient, average duration of life since the initial examination, and the percentage of those dead who have had recent follow-up studies.

TABLE III

TREATED BY IRRADIATION ALONE—26 CASES

Number of Cases	Average Duration of Symptoms Before Observation (years)	Present Status	Average Duration of Life Since First Observation (years)
2	11.5	Excellent	7.5
8	9.8	Good	4.7
5	3.8	Poor	6.3
7	7.3	Dead (26.9%)	4.1
4	7.0	No follow-up	—

The duration of symptoms before hospital admission varied from one to forty years. The average for each group has been computed from the history given by the patient. The chronicity of the disease before medical advice was sought is fairly uniform for the respective groups.

The present status of the patients has been recorded according to recent follow-up studies. The classification has been made as follows: *Excellent* includes the patients who have no complaint and have apparently returned to a normal physiologic endocrine balance. *Good* includes those patients who have one or more com-

plaints either directly or indirectly attributable to the hypophyseal adenoma. These patients are able to gain a livelihood. *Poor* combines all those patients who are incapacitated, either by the tumor or complications directly attributable to it.

The average duration of life since the first observation includes the interval from admission to the hospital through the most recent studies. In some cases a rather long preoperative period of observation preceded any specific form of therapy.

Tables I and II are self-explanatory. Table III includes several patients who were inadequately treated, chiefly due to poor cooperation of the patient. Table IV combines those cases that were considered stationary acromegaly and in which therapy was deemed unnecessary.

Analysis of the data compiled from this study indicates that the results obtained are most favorable in the groups treated by irradiation, and irradiation plus operation.

DISCUSSION

The data compiled in this study indicate that even though acromegaly is a chronic disease with spontaneous exacerbations and remissions, a guarded prognosis must be given in each individual patient. A long and useful life is not the common occurrence in the average patient. Any patient with acromegaly who consults a physician should be studied and followed with the same diligence as required for the treatment of diabetes mellitus or pernicious anemia. If there is evidence of activity of the hypophyseal adenoma, therapy should be instituted. If the tumor is quiescent and producing no visual disturbances, the patient should be warned of the signs of activity such as personality changes, nervousness, polydipsia, polyuria, and headaches. Such patients should be observed every three months and should have a complete examination, including such laboratory studies as glucose tolerance test, basal metabolic determinations, and qualitative test for prolan in the urine, as well as determination of calcium metabolism, whenever indicated. Visual field studies should be done every six months.

TABLE IV

NO SPECIFIC TREATMENT—11 CASES

Number of Cases	Average Duration of Symptoms Before Observation (years)	Present Status	Average Duration of Life Since First Observation (years)
0	0	Excellent	0
3	11	Good	7
1	3	Poor	6.5
4	12.3	Dead (36.3%)	7.3
3	8	No follow-up	—

We believe that roentgen therapy carefully and properly given is the elective method for treating a large percentage of hypophyseal adenomata, and should be tried in all cases before resorting to surgery unless there is imminent danger of permanent visual impairment. However, the radiologist should treat these adenomata only in conjunction with a competent neurosurgeon.

Radiation edema is always a possible danger and makes hospitalization and close observation obligatory during the initial series of roentgen treatments. Except for slight headaches, no untoward effects have been noted in this series of patients following roentgen therapy.

TABLE V

ANALYSIS OF THE GROUP OF FIFTY-THREE CASES OF CHROMOPHILE ADENOMA

Number of Cases	Average Duration of Symptoms Before Observation (years)	Present Status	Average Duration of Life Since First Observation (years)
3	8.3	Excellent	6.3 (5.66%)
17	8.0	Good	6.0 (32.07%)
6	4.6	Poor	6.3 (11.32%)
17	9.2	Dead	5.4 (32.07%)
10	7.4	No follow-up	— (18.98%)

SUMMARY

1. The signs, symptoms, physical findings, roentgen studies as well as the method of treatment in fifty-three cases of acromegaly studied since January 1, 1928, are presented.

2. Each patient with acromegaly requires constant medical observation and adequate laboratory examinations for detection of activity of the tumor.

3. The sella turcica was normal in 20.3 per cent of the cases by roentgen examination.

4. Sixteen patients were operated upon nineteen times without a single operative fatality.

5. A guarded prognosis should be given in all patients with acromegaly.

6. Roentgen therapy should be tried in all pituitary adenomata before resorting to surgery unless there is imminent danger of permanent visual impairment.

7. The radiologist should treat these patients only in conjunction with a neurosurgeon.

We are indebted to Dr. Harvey Cushing for permission to study this group of patients, and to Dr. Louise Eisenhardt for her kind assistance in the follow-up studies.

REFERENCES

1. Bailey, P. Results of roentgen therapy on brain tumors. Am. J. Roentgenol. & Rad. Therapy, 1925, *13*, 48–53.
2. Béclère, A. Technique, résultats, indications et contre-indications de la roentgenthérapie des tumeurs hypophysaires. *Rev. neurol.*, 1922, *38*, 808–816.
3. Berven, E. Technique at Radiumhemmet in the treatment of tumours except cancer uteri. *Acta radiol.*, 1929, *10*, 3–48.
4. Cairns, H. Ultimate results of operations for intracranial tumours. *Yale J. Biol. & Med.*, 1936, *8*, 421–492.
5. Costello, R. T. Subclinical adenoma of pituitary gland. *Am. J. Path.*, 1936, *12*, 205–216.
6. Cox, L. B., and McPhee, I. M. Observations upon metabolism of calcium and phosphorus in three cases of acromegaly, one showing osteoporosis. *M. J. Australia*, 1936, *2*, 390–396.
7. Cushing, H., and Davidoff, L. M. Pathological Findings in Four Autopsied Cases of Acromegaly, with a Discussion of their Significance. Monographs of the Rockefeller Institute for Medical Research, No. 22, 1927.
8. Cushing, H. Intracranial Tumours. Charles C. Thomas, Springfield, Ill., 1932.
9. Dott, N. M., Bailey, P., and Cushing, H. A consideration of the hypophysial adenomata. *Brit. J. Surg.*, 1924, *13*, 314–366.
10. Dyke, C. G. Roentgen ray treatment of tumors of brain and skull. *Bull. New York Acad. Med.*, 1935, *11*, 392–402.
11. Frik, K. Zur Röntgenbehandlung der Hypophysentumoren. *Strahlentherapie*, 1931, *42*, 437–452.
12. Gramegna, A. Un cas d'acromégalie traité par la radiothérapie. *Rev. neurol.*, 1909, *17*, 15–17.
13. Hare, C. C., and Dyke, C. G. Roentgen therapy of pituitary tumors; report of 20 cases. *Arch. Ophth.*, 1933, *10*, 202–225.
14. Harris, W., and Selinsky, H. Radiotherapy of pituitary tumors. *Radiology*, 1932, *13*, 777–782.
15. Heinismann, J. I., and Czerny, L. I. Die Röntgentherapie der Hypophysentumoren. *Strahlentherapie*, 1926, *24*, 331–335.
16. von Margitay-Becht, E., and Miklós, L. Hormonuntersuchungen bei Akromegalie. *Klin. Wchnschr.*, 1931, *10*, 2306–2308.
17. Pfahler, G. E., and Spackman, E. W. Further observations on roentgen treatment of pituitary tumors. Am. J. Roentgenol. & Rad. Therapy, 1935, *33*, 214–226.
18. Portmann, U. V. Personal communication.
19. Rasmussen, A. T. Percentage of different types of cells in anterior lobe of hypophysis in adult human female. *Am. J. Path.*, 1933, *9*, 459–471.
20. Towne, E. B. Roentgen-ray treatment of pituitary tumors. *Arch. Neurol. & Psychiat.*, 1926, *15*, 92–102.

Vol. 40, No. 5

DISPLACEMENT AND RECESSION OF THE CHOROID PLEXUS*

By ROBERT M. LOWMAN, M.D., *and* THEODORE J. C. von STORCH, M.D.
BOSTON, MASSACHUSETTS

WHILE calcification of the choroid plexus has received frequent mention in roentgenologic literature, displacement and subsequent recession of this structure are noted as being extremely rare. The following brief anatomic consideration of the choroid plexus is quoted from Dyke and Davidoff:

Calcification, i.e. deposits of calcium salts, most frequently occurs in the bend of the plexus, or the glomus. These structures (the choroid plexuses) are largest in the two lateral ventricles but are also present in the third and fourth ventricles. In the lateral ventricles they occupy the grooves between the basal ganglion and the thalami (sulci choroidei) on the ventricular floor and converge anteriorly, fusing after they pass through the foramina of Monro. Posteriorly, they diverge until the bodies of the ventricles are about to divide into the posterior (occipital) and inferior (temporal) horns. There each plexus makes a sharp turn and follows the ventricles around the pulvinar into the inferior horn. The portion of the plexus where the bend occurs is called the glomus. At this point the plexus tissue is most abundant. No choroid exists in the frontal or occipital horns.

Roentgenographically, calcification of the choroid plexus was first demonstrated by Schüller, and by Heuer and Dandy. Whenever calcification occurs in the choroid plexus it is practically always seen in the glomus, and Dyke and Davidoff have stated that it is invariably bilateral. The deposit of calcium in the choroid plexus may be identified in the roentgenograms by the site and characteristics of the shadow. The glomus in each lateral ventricle is normally located from 2 to 2.5 cm. lateral to the midline on the anteroposterior film.

The deposits of calcium salt in the choroid plexus usually have a very characteristic appearance. At times the shadow may be very faint and barely perceptible. The density is not uniform and may give the impression of many superimposed small dots and small curved shadows. When, however, calcium is present in larger amounts, the shadow is more or less circular and forms a cluster of dots each about 2 mm. in diameter. Dyke and Davidoff have compared the appearance of this dark cluster to a popped kernel of corn, and noted that it may reach a size of 1 cm. or more. Beals describes the shadows produced by the calcified choroid plexus as being somewhat oval, about 1 cm. in diameter without sharply defined borders. When the pineal is visualized, the three shadows stand at the angles of an isosceles triangle, the pineal at the obtuse apex and the two choroid shadows at the bases posteriorly. Because of the bilateral calcification of the choroid and the position of the plexus above and posterior to the region normally occupied by the pineal, the differentiation between the two is usually possible. Rarely, unilateral calcification of the choroid plexus must be differentiated from calcified pineal body (Fig. 1), or from pathologic calcification. In this case an encephalogram or ventriculogram will localize the calcification and outline the other uncalcified glomus.

The incidence of calcification in Dyke's series varied with the sex and again strikingly with the age of the patient. An analysis of Dyke's original figures has shown that calcification was found in 140 cases of the 2,723 cases examined, or 5.1 per cent of the total (Table 1). Beals, in a study of 86 cases, found the choroid calcified in 28 per cent of the group.

Heuer and Dandy, Beals, and Sachs and Whitney have definitely proved that these shadows seen in the roentgenograms are due to deposits of calcium in the choroid

* From the Department of Roentgenology and the Evans Memorial Department of Clinical Research and Preventive Medicine, Massachusetts Memorial Hospitals, Boston.

TABLE I

INCIDENCE OF CALCIFICATION IN CHOROID PLEXUS

Age:	1–10		11–20		21–30		31–40		41–50		51–60		61–70		71–80		over 80		Total Males	Total Females	Total
Sex:	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F			
Number of patients	108	68	203	167	245	239	285	295	267	230	214	205	87	78	20	12		2	1429 52%	1295	2724
Calcification in choroid plexus		2	4	1	6	4	17	9	22	13	21	14	15	6	4	2			89	51	140 5.1%

plexus. Heuer and Dandy noted in autopsy of one of their cases the extensive calcification of the choroid plexus and identified the shadow in the roentgenograms with this

FIG. 1. Unilateral calcification of the choroid plexus.

structure. Likewise, Beals showed by means of roentgenograms taken of the brain after removal of the choroid plexus that the calcified shadows seen prior to extirpation were no longer present.

Dyke and Davidoff, by means of encephalograms, were also able to determine the position of calcium deposits in the choroid plexus in relation to the ventricles, having rendered them visible by means of the injection of air. In several cases in which the plain roentgenograms had shown calcification in the choroid plexus the calcified masses resembling the choroid plexuses were found to have caused filling defects in the outline of the ventricles in encephalograms. These investigators noted

FIG. 2. Anteroposterior roentgenogram taken August 16, 1937, showing upward and medial displacement of the left choroid plexus.

that the size of the filling defect corresponded to that of the glomus in each one of the cases.

Most of the investigators have agreed that the presence of deposits of calcium in the choroid plexuses has no pathological significance. The defects noted in the ventricles during encephalography depended upon the size of the choroid plexus and appeared to have no association with particular diseases.

Previous observers have noted the symmetrical and usually bilateral calcification, but few have made mention of its possible importance for differential diagnosis in the localization of cranial pathology. Beals suggested that, since the choroid plexuses may be calcified in one out of four or five adults and since they occupy normally a fixed bilateral and symmetrical position, they be used in roentgenologic diagnoses. The normal position of the choroid plexus in relationship to the pineal shadow is characteristic, and it seemed to Beals to be a justifiable conclusion that any definite displacement should be apparent and have a diagnostic value comparable with that accepted for the shift of the pineal body and the falx. In the series of cases considered by Dyke and by Beals, these observers noted no displacement of the choroid. Newell, however, has noted one instance in which one choroid plexus was displaced downward by pressure of a cerebral tumor.

The following case is presented not only because of its special interest in noting the displacement of the calcified choroid plexus, but also because of the presentation by means of serial roentgenograms of the subsequent partial recession of this structure to a more normal position.

Fig. 3. Lateral roentgenogram taken August 16, 1937. The upper arrow points to the left choroid plexus which is displaced upward.

Fig. 4. Anteroposterior roentgenogram taken August 31, 1937, showing slight shifting (recovery) of left choroid plexus downward and to the left.

Case 237,651. J. W. L., white, male, aged sixty-two, married, was admitted July 27, 1937, to the Evans Memorial in a very confused state. For the previous two weeks, prior to admission to the hospital, he had exhibited mild, rather vague, but progressive mental changes. Three days before admission, he became confused, incoherent and weak in the right arm with drooping of the left angle of the mouth. The following day he was somewhat improved and seemed to recognize his family, though partial confusion persisted. The weakness of arm and left side of the face had apparently disappeared.

The family history and past history were non-contributory.

Physical examination revealed a well-nourished male with peripheral arteriosclerosis and a blood pressure of 120/80, normal pulse and respiration and an irregular fever occasionally reaching 101°F. He was confused, anxious and uncooperative although not stuporous. No complaints could be elicited. The patient was aphasic in both motor and sensory spheres. Signs of upper motor neurone involvement were

Fig. 5. Anteroposterior roentgenogram taken September 10, 1937, showing further recession of the left choroid plexus.

present in both legs, more predominant in the right leg with slightly hyperactive reflexes of the right arm. No involvement of the cranial nerves was noted, nor could any sensory defects be found. Ophthalmoscopic examination revealed haziness of the edges of both optic discs, but no definite papilledema was found.

The blood counts, serology, urinalyses, phenolsulphonephthalein excretion and electrocardiograms were non-contributory. The lumbar cerebrospinal fluid examinations on admission showed a normal pressure with 23 red blood cells per cc., total protein of 107 mg. per cent and negative Wassermann reaction. Eight days later, the second spinal fluid examination, showed a normal pressure, definite xanthrochromia, 4 lymphocytes and a total protein of 62 mg. per cent. Ten days following admission, the spinal fluid examination showed a pressure of 250 mm. of H_2O, 26 red blood cells, 8 lymphocytes and 3 polymorphonuclears per cc. were present. The total protein was 35 mg. per cent. The lumbar puncture repeated on the thirty-fifth day following admission showed normal pressure and a total protein of 37 mg. per cent. Because of trauma, 140 red blood cells per cc. were found.

During his stay in the hospital, his confusion diminished and his aphasia regressed somewhat although later he developed paranoid ideas. Signs of motor involvement disappeared and his strength improved. The location of the lesion was considered to be in the left temporal lobe. The diagnosis lay between cerebral vascular thrombosis, cerebral hemorrhage and cerebral neoplasm. Neither neurologic nor neurosurgical consultants felt that a hemorrhage into a neoplasm could be definitely excluded. Both, however, considered that a cerebral hemorrhage was the most likely possibility in view of the onset, signs, course and especially the roentgenograms. Operation was therefore postponed pending subsequent alterations in the roentgenographic examinations.

Twenty days after admission (August 16, 1937) the roentgenographic report was as follows: Skull: The vault is not remarkable. There is bilateral calcification of the choroid plexus presenting mottled areas of calcification about 1.5 cm. in diameter. The calcified area on the left in the anteroposterior view is displaced upward and toward the midline. The nearest border of the right calcified area is 2 cm. from the midline; that of the left is 1 cm. from the midline. In the stereoscopic plates the left calcified shadow appears to be displaced upward, apparently due to tumor in the left

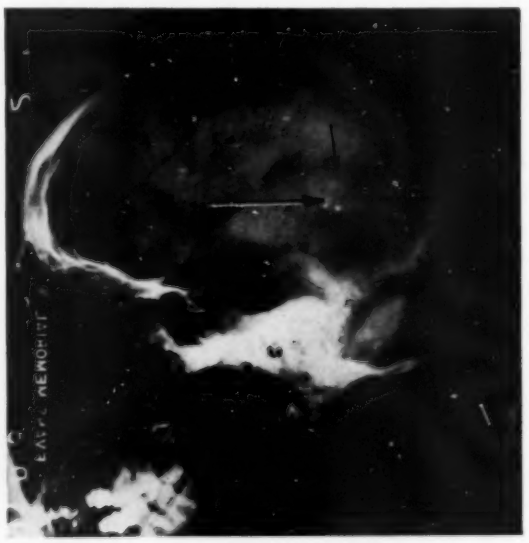


Fig. 6. Lateral roentgenogram taken September 10, 1937, showing downward recession of the left choroid plexus, both sides now being almost superimposed.

cerebral hemisphere. The sella turcica appears normal in size and contour. There are several curvilinear streaks of calcification lying above the anterior clinoid process. Viewed stereoscopically, these calcified streaks appear to lie at different levels, the left being more elevated from the floor of the sella than is the right. This is apparently calcification in the wall of the internal carotid consistent with marked arteriosclerosis. The elevated area of calcification on the left is thought to be an aneurysmal dilata-

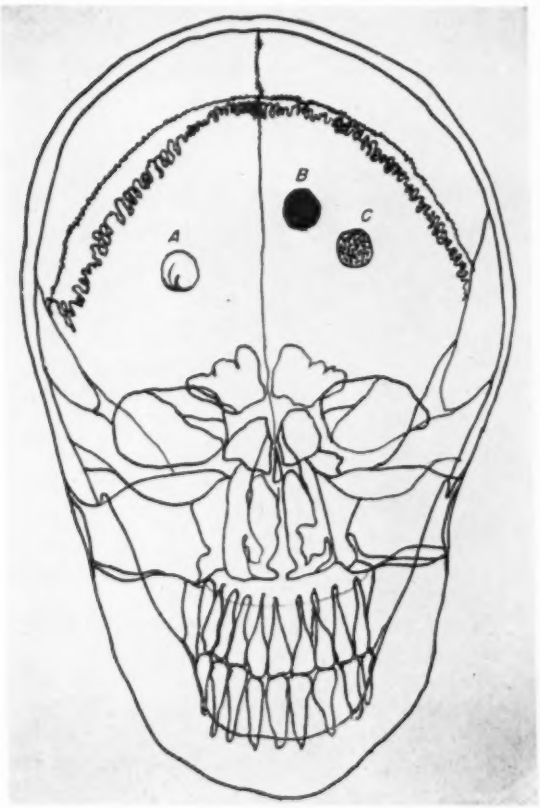


Fig. 7. Tracing of anteroposterior roentgenograms made August 16 and September 10, 1937. *A*, right choroid plexus lying in normal position; *B*, left choroid plexus as seen on August 16, showing the upward and medial displacement; *C*, left choroid plexus as seen on September 10, showing return to position more nearly approximating normal.

tion of the left carotid artery in the region of the sella (Figs. 2 and 3). The possibility of cerebral hemorrhage as a cause of displacement of the left choroid plexus should be considered.

August 19. The vault appears normal. No change noted in the appearance of the skull since last examination.

August 20. No shifting of the calcified areas noted.

August 31. There is a slight shift of the left area of calcification laterally to the left (Fig. 4).

September 2. No marked shift in addition to that noted on August 31.

September 10. The areas of calcification seen in the anteroposterior view appear to lie equidistant from the midline. The left area, however, does not appear to lie at the same level as the right. In addition, in the lateral films, the left area of calcification has almost superimposed itself on the shadow on the right (Figs. 6 and 7). Recession of the displaced choroid is consistent with resorption of hemorrhage.

The plates were reviewed by Dr. Merrill C. Sosman who considered that they were diagnostic of an aneurysm of the left internal carotid artery and displacement of a calcified choroidal glomus by cerebral hemorrhage with gradual replacement as the hemorrhage and edema became absorbed.

The patient was discharged greatly improved but not completely relieved.*

DISCUSSION

Bilateral calcified choroidal plexuses lying in the atria of the lateral ventricles are occasionally seen in normal subjects and should not present any difficulties to the competent roentgenologist. When only one choroid plexus is calcified, as occasionally happens, it may be necessary to resort to encephalography or ventriculography in order to identify the mass. When both are present but unequally situated, the problem arises as to whether they are bilateral calcifications due to neoplastic or vascular pathology, or whether they are glomi displaced by a neoplasm or by a cerebral hemorrhage.

The characteristic contour, density and location of at least one glomus should differentiate these bodies from pathologic masses. When one glomus is displaced in such fashion as in this case, it offers a natural means whereby we may learn whether the displacing mass is neoplastic or hemor-

* This patient was seen on January 24, 1938, and again on May 27, 1938. He appeared well physically and mentally, and no abnormal neurological signs were demonstrated. Roentgen examination at this time showed the calcified choroid plexuses to be in their normal position.

rhagic. Such differentiation is obviously of utmost importance.

It was pointed out in this case that if a tumor were present further displacement might be expected, whereas if the dislocation were produced by a fresh hemorrhage recession might be expected. Operation was postponed and such recession took place. The patient's course in the hospital helped to confirm the diagnosis of left internal carotid aneurysm without signs and left temporal lobe cerebral hemorrhage.

SUMMARY

This case is presented as the first report in the literature of displacement of the choroid plexus with subsequent return to a more normal position. Displacement was probably due to a localized cerebral hemorrhage.

We wish to express our thanks for the assistance rendered by Dr. Reginald Fitz and Dr. Merrill C. Sosman.

REFERENCES

1. BEALS, J. A. Intracranial calcification, probably of choroid plexus. *Radiology*, 1930, *15*, 268–273.
2. CAMP, J. D. Intracranial calcification and roentgenologic significance. AM. J. ROENTGENOL. & RAD. THERAPY, *1930*, *23*, 615–624.
3. CAMP, J. D. Roentgenological manifestations of intracranial disease. *Radiology*, 1929, *13*, 484–493.
4. COURVILLE, C. B., and ADELSTEIN, L. J. Intracranial calcification, with particular reference to that occurring in gliomas. *Arch. Surg.*, 1930, *21*, 801–828.
5. CROUSE, H. W. X-ray in neurological diagnosis: its shortcomings and possibilities. AM. J. ROENTGENOL. & RAD. THERAPY, 1923, *10*, 437–444.
6. DAVIDOFF, L. M., and DYKE, C. G. An improved method of encephalography. *Bull. Neurol. Inst. New York*, 1932, *2*, 75–94.
7. DYKE, C. G. Indirect signs of brain tumor as noted in routine roentgen examinations; displacement of the pineal shadow. AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *23*, 598–606.
8. DYKE, C. G., and DAVIDOFF, L. M. Demonstration of normal cerebral structures by means of encephalography; choroid plexuses. *Bull. Neurol. Inst. New York*, 1932, *2*, 331–346.
9. HEUER, G. J., and DANDY, W. E. Roentgenography in localization of brain tumor, based upon a series of one hundred consecutive cases. *Bull. Johns Hopkins Hosp.*, 1916, *26*, 311.
10. MEYER, S. Ueber die Struktur, das Vorkommen und die Entstehung der Sandkörper. *Virchow's Arch. f. path. Anat.*, 1896, *143*, 196–223.
11. NAFFZIGER, H. C. A method for localization of brain tumors—the pineal shift. *Surg., Gynec. & Obst.*, 1925, *40*, 481–484.
12. NEWELL, R. R. Calcification in brain tumors. *Surg. Clin. North America*, 1923, *3*, 775–786.
13. NEWELL, R. R. Discussion. AM. J. ROENTGENOL & RAD. THERAPY, 1930, *23*, 629.
14. O'SULLIVAN, J. Some rarer intracranial calcifications and ossifications. *Brit. J. Radiol.*, 1925, *30*, 295–304.
15. ROTHSTEIN, J. L. Calcification of choroid plexus. *Am. J. Dis. Child.*, 1936, *51*, 123–130.
16. SACHS, E., and WHITNEY, C. Calcification in choroid plexus with consideration of their significance. *Arch. Neurol. & Psychiat.*, 1929, *21*, 533–541.
17. SCHÜLLER, A. Röntgendiagnostik der Gehirnkrankheiten. 1914, 343.
18. STRÖM, S. Ueber die Röntgendiagnostik intrakranieller Verkalkungen. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1919-1921, *27*, 577–601.
19. VASTINE, J. H. The pineal body; roentgenological considerations. AM. J. ROENTGENOL. & RAD. THERAPY, 1933, *30*, 145–155.
20. VASTINE, J. H., and KINNEY, K. K. The pineal shift as an aid in localization of brain tumors. AM. J. ROENTGENOL. & RAD. THERAPY, 1927, *17*, 320–324.

Vol. 40, No. 5

STIPPLED EPIPHYSES WITH CONGENITAL HYPOTHYROIDISM (CRETINOID EPIPHYSEAL DYSGENESIS)*†

By WILLIAM ANTHONY REILLY, M.D., *and* FRANCIS SCOTT SMYTH, M.D.
SAN FRANCISCO, CALIFORNIA

THERE have been scattered reports in the literature concerning epiphyseal stippling. We present this study with the intention of clarifying, at least in part, the etiology and nature of this interesting roentgenological finding. The condition found in dwarfed children is recognized by roentgen film and may be more frequent than is now supposed.

While there are a few previous descriptions of the condition, these are entirely in the foreign literature. Langhans,[1] in 1909, described the occurrence of stippled epiphyses in true cretins. His report was based on the study of cadavers. v. Seemen[2] and Looser[3] (1928) published detailed studies on the clinical and roentgenographic phases of the disturbance in true cretins. Fairbank[4] more recently described what we believe is the same condition. However, this author, while emphasizing the relation to dwarfism, failed to recognize any thyroid disturbance. We wish to cite our own studies on this point, but since true cretinism is not recognized as occurring in this country, we have resorted to the term "cretinoid" to signify a congenital basis for the thyroid hypofunction. Finally, since the condition is not widely recognized as yet, we would admit the possibility of stippled epiphyses occurring without hypothyroidism, although suggesting that therapeutic test administration of thyroid may, even for such cases, prove of value.

REPORT OF CASE

In September, 1933, A. D., a boy, aged twelve, was brought to the University of California Hospital Out Patient Department because of mental deficiency, stunted growth and a waddling gait of several months' duration which was aggravated after walking. He had the typical appearance of marked hypothyroidism, the height of a six-year-old boy and a bone age of between two and six years. The waddling gait and bone age directed our attention to the femoral epiphyses. The interpretation of the films is as follows (see Figs. 1 and 4):

"The epiphyses, particularly those of the heads of the femora and humeri, and, less noticeably, the lower epiphyses of these bones, are granular in appearance, having multiple ossification centers. The other epiphyses are fragmentary. There is flaring of the costal margins and long bone diaphyseal ends, marked coxa vara, and maldevelopment of the vertebral bodies, and marked squaring of the skull, suggesting old rachitic deformities. The metaphyseal borders are roughened, further suggesting rickets. The eburnated diaphyseal ends of the phalanges suggest scurvy. There is extensive spina bifida occulta. Delayed development of permanent teeth. The shafts of the long bones show fairly normal structure and are well mineralized. *Impression:* Hypothyroidism. Severe old rickets and other evidence of prolonged nutritional disturbances. The bone age by averaging could be set at about five years. Actually it varies from two to six years with reference to individual epiphyses."

On admission this boy had a slightly negative daily calcium balance (258 mg.) and a positive retention of phosphorus (346 mg.), a very good glucose tolerance, normal blood chemistry (calcium, phosphorus and cholesterol) but a high phosphatase (14.4 Kay units).

He grew 19 cm. after two and a half years of irregular thyroid medication (gr. 3/4 daily), dicalcium phosphate, and viosterol, his appearance had improved, the epiphyses were average for seven years, his intelligence quotient was

* From the Department of Pediatrics, University of California Medical School, San Francisco. Aided by a grant from the Christine Breon Fund.

† The authors wish to thank the Department of Roentgenology for assistance in the interpretation of the films and for advice.

unchanged but his reactions were quicker and his basal metabolic rate when therapy was discontinued was −27 per cent. An initial anemia had rapidly disappeared and calcium and phosphorus metabolism were normal. The roentgen findings at this time were as follows:

Another patient, E. P., with marked hypothyroidism, and the same type of epiphyseal stippling, came to our attention six months after the first patient. This girl, aged eleven and a half, had had marked untreated thyroid deficiency from early infancy. She had the typical

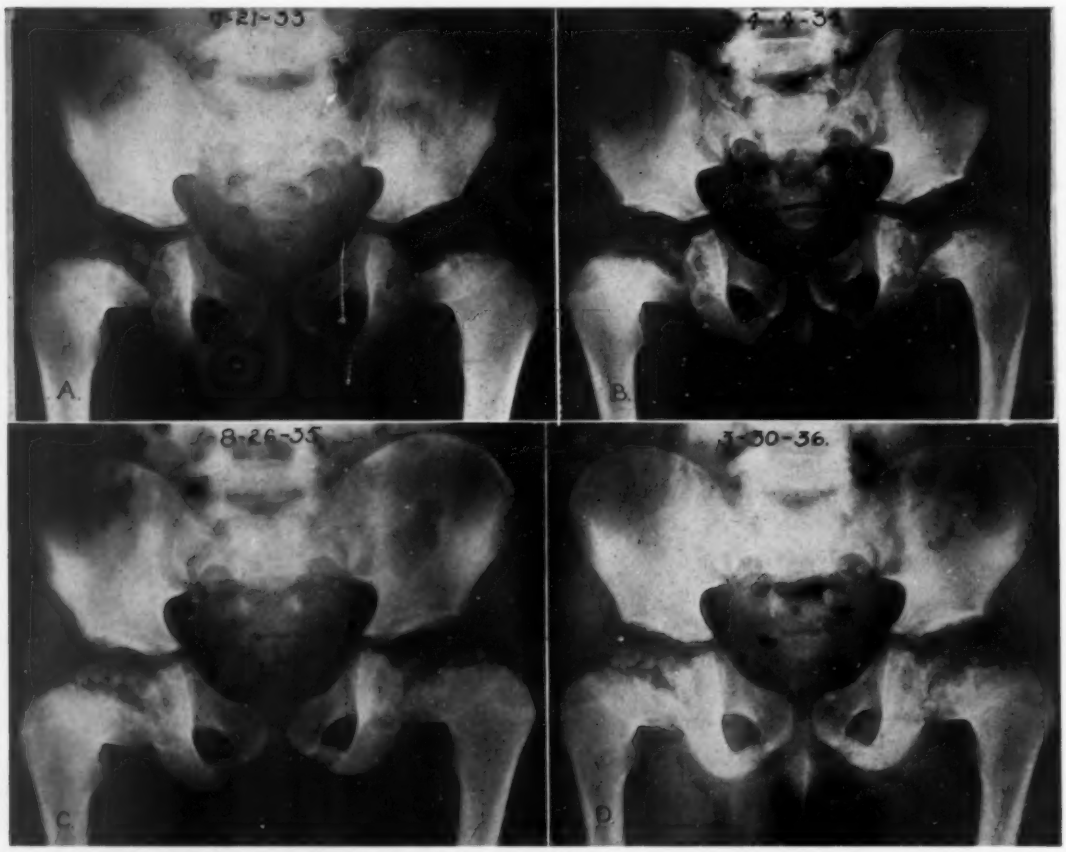


FIG. 1. Case A. D. Gradual lessening of stippling occurred progressively. The epiphyses would have formed more normally if the patient had been more faithful to thyroid therapy.

"There has been a slight increase in the calcification of the epiphyses of the heads of the femora. The epiphysis for the capitellum also shows slight increase in size and increased calcification."

Seven months later the report on the bone age was: "The epiphyses for the distal end of the ulna and the trapezoid have appeared; also union of the ischium and pubis is beginning to occur, indicating a bone age of nearly seven years. The epiphysis for the os calcis is not developed yet indicating bone age of less than eight. All of the previously described epiphyses have developed in size, and the bones have increased in length (Fig. 1). This is most marked of the metacarpal and phalangeal bones."

somatic appearance, failure to grow during the previous two or three years, the average height of a four-year-old child and epiphyseal age between three and six years. There was no detectable physical sign of epiphyseal maldevelopment, but a roentgenographic study of the heads of the femora was requested. Several of these reports of the earlier months of observation follow:

March 30, 1934, Bone Age (Pelvis and Elbow) (see Fig. 2):

"The epiphyses for the heads of the femora are very granular, the appearance being the same as that of A. D. The epiphysis for the trochanter has not yet appeared and should appear at nine years. The epiphysis for the great-

er trochanter which should appear before five years has not appeared. The epiphysis for the capitellum of the humerus, which appears from seventeen months to two years is moderately well developed. The epiphysis for the medial epicondyle of the humerus which should appear at five years is quite small. *Conclusion:* The bone age is below six years. Skull: The sella turcica appears normal."

April 5, 1934, Hand:

"The ossification center for the lunate should appear at four years but is not present. The epiphyses for the phalanges and metacarpals and the ossification center of the triangularis, which should appear at three years, are all present. There is a peculiar development of the epiphyses for the metacarpals and the bone structure of the fifth metacarpal is somewhat unusual."

May 15, 1934, Pelvis to show upper ends of femora:

"The capital epiphyses of the femora appear the same as at the time of the last examination March 30, 1934. The epiphysis of the left greater trochanter has not appeared and is granular in character."

Fig. 2. Case E. P. Compare *A* and *B* noting the improvement of epiphyseal formation within six months. *C* and *D* are further stages of improvement and *D*, particularly, the normally formed capital epiphysis.

June 30, 1934, Pelvis, Right Hand, Right Knee:

"Union at ischium and pubis. The epiphyses of the greater trochanters have appeared and are granular in nature. The capital epiphyses of the femora are larger and somewhat more compact but are still granular in appearance. Only three bones of the carpus are ossified as before. The epiphyses of the tibia and femur at the knee are well ossified but have a mottled appearance similar to that described in other sites. There is a submetaphyseal band of in-

creased density of the tibia and femur at the knee with shorelines and flaring suggesting an old rickets."

She, too, had a slightly negative daily calcium loss (157 mg.) and slightly high phosphatase (9.1 Kay units). The negative calcium loss became greater after the first month of thyroid,

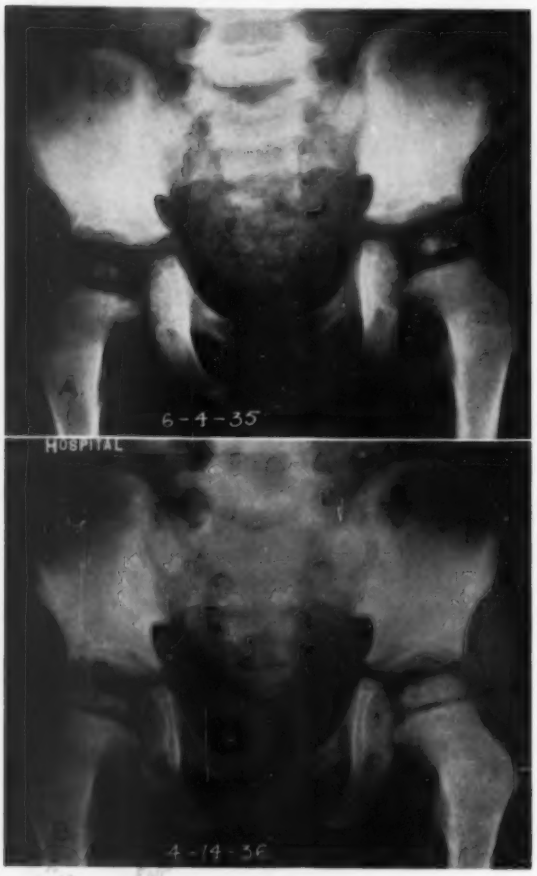


FIG. 3. Definite improvement by thyroid therapy can occur in as short a time as six months. This happened in D. R.

dicalcium phosphate and viosterol therapy. Demineralization had been progressing in the skeleton before any therapy was started and seemed to stop after her first six months of therapy. At this time the roentgenogram showed:

September 6, 1934, Pelvis:

"There is considerably more calcium present and the epiphyseal lines are getting narrower. The granular appearance of the epiphyses is still much in evidence.

"*Right hand:* No essential change except for slight increase in size.

"*Skull:* No change."

December 18, 1934, Bone Age:

"Since the examination of last June the distal epiphysis of the ulna has appeared and taken quite definite shape and the ossification centers for all of the small bones of the carpus have appeared. The epiphyses for the phalanges and metacarpals have taken on a more normal appearance. The epiphyses for the trochlea and olecranon are beginning to be in evidence. These changes would place the bone age as now somewhere about nine years."

Pelvis: "The heads of the femora have improved considerably since the last examination. The surfaces have become much smoother and the internal structure less moth eaten."

In the course of therapy a pyuria was found to be caused by marked bilateral hydroureters and hydronephrosis. It was successfully treated medically.

Two years after starting therapy and continuing it faithfully, her height had increased 12.5 cm. After discontinuing therapy for three months her basal metabolic rate was −30 per cent.

D. R., a boy, aged five, had recognizable and untreated hypothyroidism for three years (see Fig. 3). He had not grown normally for two years, was 92.5 cm. tall (average for three years) and had a slightly waddling gait. Physically he resembled well-established hypothyroidism in his facies, skin, behavior, etc.

There was no ossification of the epiphysis for head of the radius or greater tubercle of the humerus. In the ossified epiphyses there was an unusual particularly fragmented appearance as if the laying down of new bone had been rather irregular. In the heads of both femora, calcium was being laid down as small, fragmented nuclei of bone over an area less than 1 cm. in diameter. The roof of the acetabulum appeared distinctly abnormal in that it was shallow with an unusually wide zone of cartilage which had not been calcified. The necks of both femora were distinctly broadened and thickened, having the appearance of coxa vara. The epiphyseal age was about two years.

Four months later, the first re-examination by roentgenogram showed that the previously small fragmented epiphyses forming the heads of both femora had increased to double size; newly appearing epiphyses (wrists, phalanges, etc.) were not fragmented in their development; the epiphyseal age was four years.

After one year of continuous treatment (gr. ½ thyroid substance, dicalcium phosphate and

viosterol daily), there was a remarkable improvement in the size and calcification of the heads of the femora. There was approximately twice as much calcium present. Epiphyseal age was between four and five years. Newly forming epiphyses were appearing and developing normally without the characteristic stippling or fragments observed before therapy was started. At the time he was six years of age and had grown 8.75 cm. The dosage of thyroid substance was purposely kept at ½ grain daily so that growth of epiphyses and shafts of bones would not be too rapid and possibly leave him more dwarfed after full skeletal growth has been attained than he undoubtedly will be despite this plan of therapy.

We have data on two additional cases studied for longer periods. Their epiphyses developed normally during therapy and the ultimate outcome was favorable.

A fourteen-year-old boy (courtesy of Dr. W. Palmer Lucas) had been a typical sporadic cretin, probably most of his life. He had many of the severe physical and mental stigma of marked hypothyroidism and was only 105 cm. tall. Marked pronation of the feet was the only physical evidence of the abnormally stippled capital epiphyses; his basal metabolic rate was only −8 per cent.

Roentgenograms at fourteen years showed that the epiphyses of the upper and lower extremities were poorly formed and had an unusually porous appearance; the heads of the femora were represented by small amounts of irregular calcifications. The epiphyseal age was between four and five years.

At seventeen and a half years the capital epiphyses were forming more normally but there was a nearly right angulation of the neck of the femur and a great increase in its thickness. (Such a type of coxa vara was present in 3 of our 5 cases.) Latest roentgenograms made at the age of nineteen showed epiphyses, developed during five years of therapy, had formed normally.

A boy first observed at the age of fifteen (courtesy of Dr. Hans Lisser) had marked hypothyroidism which dated from about his second year. It was very evident in his dwarfism, facies, mentality (seven years mental age) and infantilism. He has been under constant thyroid treatment for fifteen years and is now thirty years of age.

At the age of fifteen years roentgenograms showed that only the capital epiphyses had the irregular fragmented appearance. The flatness of the epiphyses and angulation of the neck (1921) were suggestive of Legg-Calvé-Perthes' chondrodystrophy. There were no abnormal physical findings. The epiphyseal age was six years. He had gone through several years of irregular thyroid therapy. Up to the age of seventeen and a half years most of his newly forming epiphyses had not developed with stippling. The os calcis developed during this time, at the age of twenty had calcified homogeneously.

The capital femoral epiphyses were found to be homogeneous for the first time at the age of eighteen. Subsequently no other developing epiphyses have formed by stippling. He had grown 43.75 cm. during the first four years of therapy and bone age had progressed from six years to over fourteen years. Previous to therapy there had been a growth of only 13.75 cm. in five years. In 1936, when the patient was thirty years of age and had had fifteen years of faithful treatment, there was no physical evidence of abnormally formed epiphyses. This is the longest known observation available for this condition. It illustrates the eventual normal outcome for epiphyses developing after initiation of thyroid therapy and the satisfactory ossification structure and morphology of epiphyses developing but not fully formed or ossified before therapy began.

We wish to discuss a few aspects of this condition—the differential diagnosis and clinical course.

DIFFERENTIAL DIAGNOSIS

For many reasons tuberculosis can be excluded. There is no severe pain, fever, leukocytosis, local swelling or heat, or abscess formation. The roentgenograms show no destructive process, there is progressive new bone formation without sclerosis and tissue sections are entirely devoid of tubercles or tubercle bacilli.

The condition of the femoral head is nearly always confounded with the epiphysitis of the capital epiphysis described by Calvé, Legg and Perthes. It is true that the roentgenographic picture in both conditions may be nearly identical, but the following details are different:

	Legg-Calvé-Perthes' Disease	*Cretinoid Epiphyses*
Loci of calcification	Not often	Always
Distribution	Usually unilateral	Most frequently bilateral
Course	A destructive process of formerly uniform epiphyses	Not destructive; the epiphysis forms from loci
Pathological changes	A destructive, aseptic necrosis	Very little if any necrotic change
Response to thyroid substance	None—continues to destroy progressively. Immobilization by cast, rest or surgery is usually necessary	Healing or cure possible within six months—usually does not require immobilization

Dysgenesis occurs in other epiphyses of the skeleton and is often bilateral (see Fig. 4). We have seen it in both ends of the humeri, ulna, radii, tibia, fibula and in the vertebral column. Such a dissemination does not characterize Legg-Calvé-Perthes' disease. We do not believe that dysgenesis is the concomitant occurrence of the various types of "aseptic necrotic" osteochondritis in the same patient. Furthermore, osteochondritis does not show any appreciable response to thyroid therapy. The differential points for the capital epiphysis hold for other epiphyses.

CLINICAL COURSE

On first discovering these epiphyseal formations one is inclined to expect further changes and even destruction. The persistence of unused cartilaginous masses on the surface of the epiphyses and spongious bones, especially on joint surfaces of the femoral heads, doubtless is the cause of the frequent occurrence of severe forms of deforming arthritis of the joints, with destruction of the head of the femur, in adult cretinism. The unossified cartilaginous masses on the surface of the femur cannot bear much weight and this leads to wearing "threadbare" the surface of the epiphysis. Three of our 5 cases showed a deformity in the shape and angulation of the neck of the femur.

Great improvement follows small doses of thyroid substance even within six

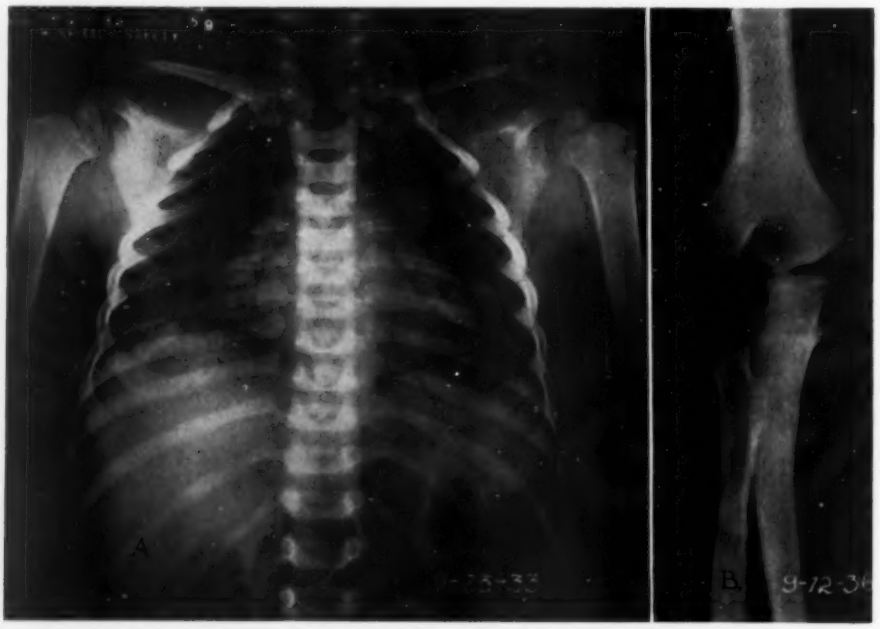


FIG. 4. Stippled epiphyses are often bilateral and can occur at several sites. Besides the hip, A. D. had these changes in the elbows and shoulders.

months, and clinical cure can sometimes be effected in one year. Under therapy a new epiphysis can develop normally without stippling. Thus D. R., after six months' ingestion of ½ grain of thyroid substance daily, showed great improvement, and at the end of the year it was estimated that approximately twice as much calcium was deposited as before treatment. Purposely the dosage was kept a good deal below the greatest tolerance so that his epiphyses would not age too quickly. Should rapid formation of epiphyses persist for many years, the epiphyses might close before the eighteenth year, leaving the patient more dwarfed than he was destined to be.

Coincidentally, the patients received 10 to 20 drops of viosterol 250 D, daily, and 1 drachm three times daily of the following:

Dicalcium phosphate	30/
Lactose	30/
Lemon juice	30/
Water to	160/

This supplied 60 grains of dicalcium phosphate daily, probably a normal intake, replacing calcium lost by the action of thyroid substance. Viosterol was used to help in the utilization of the salt. This mixture of dicalcium phosphate has a balanced amount of calcium and phosphorus, and is readily absorbed in an acid medium, lactose being added for palatability.

Patients frequently omitted the viosterol and salt mixture and used only the thyroid substance. We feel that the improved formation of the epiphyses was attributable to the thyroid substance.

SUMMARY

In some children having severe hypothyroidism resembling that of the true cretins, many of the epiphyses develop abnormally and have the following characteristics: There are multiple loci of calcification; the calcification is slow; abnormal epiphyses occur in many parts of the skeleton; the distribution is usually bilateral; the process generally occurs in the capital epiphyses; and there may never be normal structure without treatment. When thyroid extract is used normal epiphyses develop in from six to twelve months. Dysgenesis is often mistaken for the chondrodystrophy of Legg-Calvé-Perthes.

References

1. Langhans, T. Anatomische Beiträge zur Kenntniss der Cretinen. *Arch. f. path. Anat.*, 1897, *149*, 155–187.
2. v. Seemen, H. Osteochondropathia cretinoidea (Osteoarthrosis hypothyreotica). *Arch. f. klin. Chir.*, 1928, *152*, 616–630.
3. Looser, E. Lehrbuch der Röntgendiagnostik. Georg Thieme, Leipzig, 1928, p. 362.
4. Fairbank, H. A. T. General diseases of the skeleton. *Brit. J. Surg.*, 1927, *15*, 120–142.

A TYPICAL FORM OF HUMERUS VARUS

ADOLESCENT HUMERUS VARUS*

By MICHAEL S. BURMAN, M.D.

NEW YORK CITY

REPORT OF CASE

MIRIAM L. (No. G 7626), aged twelve, was delivered by breech presentation. The mother recalls that something happened to the baby's left arm, so that it was bandaged to the body soon after birth. No roentgenogram was taken. The hospital record makes note of a disability of the left arm, attributing it to a "spastic paralysis" of that arm. The succeeding years indicated this diagnosis wrong. It was only recently that the mother had observed the left arm shorter than the right.

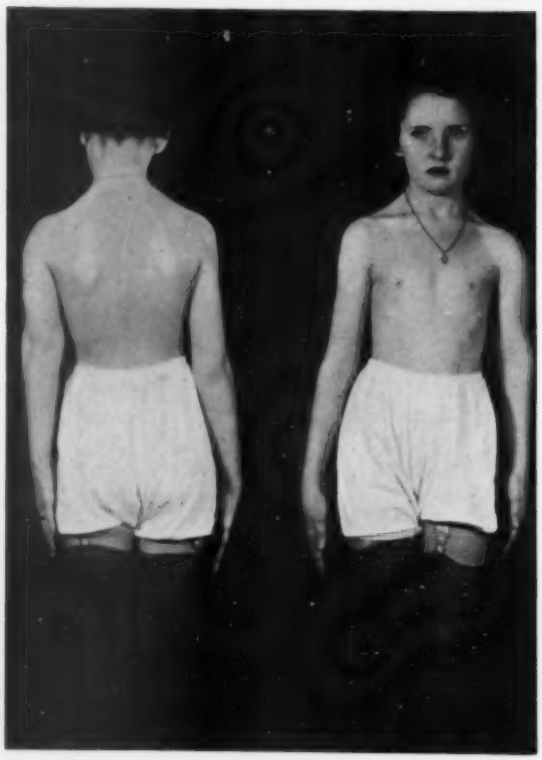


FIG. 1. The appearance of the patient on January 28, 1937.

The child was first brought to the clinic on June 18, 1935, not because of the disability of the arm but because of a mild spinal curvature, which had been noted for a year. The right shoulder was higher than the left and the right scapula was more prominent. A very mild curvature of the upper dorsal spine to the right and of the lower dorsal and lumbar spine to the left was present. The curve was easily corrected voluntarily and by manipulation. Roentgenogram of the spine showed no scoliotic deviation. Under proper postural exercises, she improved.

The infirmity of the left shoulder was first recognized on December 7, 1935. The left humerus was distinctly shorter than the right, measurement indicating a shortening of $1\frac{1}{2}$ inches. The right humerus measured 11 inches from acromion to internal epicondyle, the left $9\frac{1}{2}$ inches. The total arm length difference was $2\frac{1}{4}$ inches, measurements being taken from the acromion tip to the tip of the ulnar styloid; the right arm length was $18\frac{3}{4}$ inches, the left $16\frac{1}{2}$ inches, indicating a forearm shortening of $\frac{3}{4}$ inch. The head of the humerus felt much larger than normal and was more than usually mobile in the joint. It seemed that the head was subluxated anteriorly, and inferiorly. On forward flexion of the shoulder, it slipped back posteriorly. The joint space was widened slightly. Motions of the left shoulder were restricted. Abduction in the frontal plane of the body could not be carried out actively; passively it did not exceed 45° because of contact of the humeral head against the acromion process. Sagittal abduction was possible to 120° actively. Both internal and external rotation were slightly restricted, internal rotation more so. Forward and backward motion of the shoulder was normal. The deltoid seemed shorter and rounder than normal. A slight atrophy of the supraspinatus muscle existed. The humeral head was slightly tender on palpation.

Roentgenograms of both shoulders were taken. The right shoulder was normal. The left humeral head was bent medially and inferiorly in varus and fitted into a groove at the upper and medial end of the humerus. The place of grooving was metaphyseal and at the level of the surgical neck of the humerus. The medial cortex of the humerus was absent at that point.

* From the Hospital for Joint Diseases, the Service of Dr. Leo Mayer.

The outer wall of the groove was formed by the lateral humeral cortex, which was not thickened at that level. No periostitis was present. The outline of the humeral head was altered and there was a decrease in its radius of curvature. The flattened head was now formed of two ovals, instead of one, which met at a point opposite the midpart of the glenoid. The upper oval was shorter and more flattened. The head was viable and showed no aseptic necrosis. The epiphyseal line was more vertically placed. The premature closure of the inferior part of the epiphyseal plate seemed certain. The anatomi-

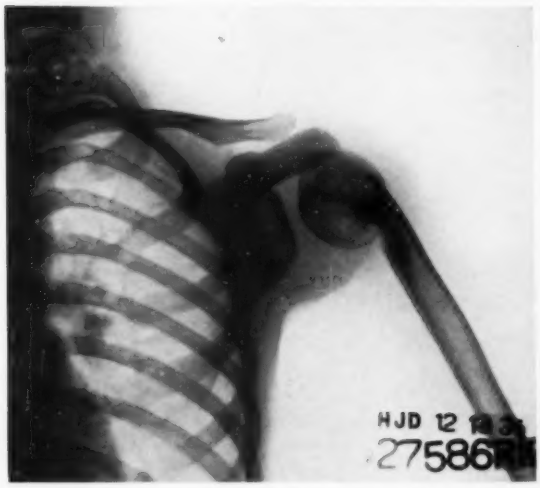


FIG. 2*A*. Roentgenogram of the varic shoulder, December 7, 1935.

cal neck of the humerus was more vertically directed. There was elevation of the greater tuberosity. The angle of inclination was decreased from the normal of 165° to 48°. The glenoid fossa was normal. The joint space was broader than usual. The humeral shaft showed definite underdevelopment.

The child was again examined on January 28, 1937. The shortening of the left upper extremity was now 2 inches. The irregular head of the humerus could be felt bent in varus. Another roentgenogram of the shoulder was taken. The head was bent in varus as indicated previously. Medial flexion of the humerus at the surgical neck was now present. The head fitted into a smaller groove lined laterally by sclerotic bone. The region of the surgical neck was sclerotic. A large beak of bone was noted on the floor of the groove medially. A small cyst-like area was seen laterally in the region of the surgical neck. The lower part of the epiphyseal line was fused,

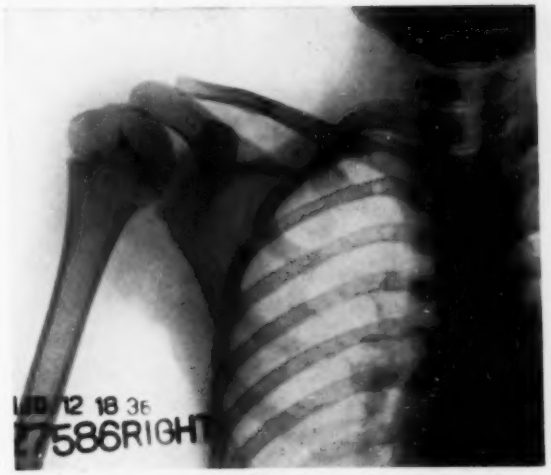


FIG. 2*B*. Roentgenogram of the normal right shoulder, December 7, 1935.

the upper part still unfused. Beaking of the margins of the superior part of the epiphyseal line was present.

Only 8 cases of this disease have been recorded (Angelotti, Seifert, Satta, Nicotra, and Stropeni). Five cases were reported in girls, the youngest of whom was twelve years, the oldest eighteen; the average age was between twelve and fourteen years. Three boys showed this deformity. The youngest was twelve and the oldest seventeen. The other boy was sixteen. It is therefore a disease of adolescence. The left humerus was affected in 5 of the 8 cases. All

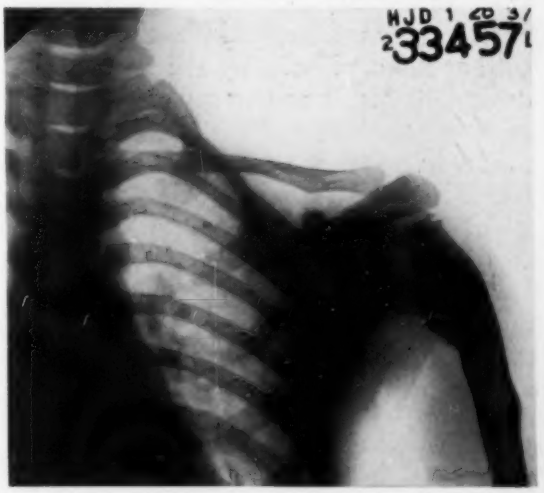


FIG. 3. Roentgenogram of the varic left shoulder, January 28, 1937.

of these patients were normal and healthy, except one who had an anemia with splenomegaly due to malaria.

The obvious thing which should have been noted is the shortening of the arm. Yet, it is surprising how long it took before either the patient or the parents saw a discrepancy in length. The deformity is usually observed at twelve to fourteen years of age, but in one case it was seen at the age of six, indicating that, though the genesis of this deformity occurs before adolescence, the rapid growth of this period brings out the difference in the length of the two arms. In some cases, no statement is made as to when the deformity was first observed. Two cases were first discovered by physical training instructors.

The birth history was said to be normal in 3 cases, but was not considered significant of mention in the other five. It is mentioned in the history of the girl of eighteen, that she fell in infancy from the arms of her nursemaid, striking the left side of the body. In no case is there a history of a strong, direct trauma to the shoulder. In 4 cases, no note of any trauma at all is given. A slight fall several years before in school is mentioned in one case, the pain in the shoulder appearing about a week after gymnastic exercises. Another patient, while carrying a bucket of water three years before her first examination, experienced sudden, sharp pain in the shoulder, so that she could not use the arm for three days. The arm was thereafter weaker and became gradually shorter. This suggests a pathological fracture and this belief is amplified by the history of another case in which an unusual muscle force was applied to the shoulder so that the arm had to be kept quiet for a few days. A boy of seventeen had noted a quickly subsiding sudden pain in the right shoulder nine years before.

Pain may or may not be present and is never more than a dull ache. The arm may feel weaker, and even as if it were paralyzed, as in one case.

The head of the humerus appears to be subluxated antero-inferiorly but lies within the glenoid; it is more easily palpated and apparently larger. The joint space is widened so that it may be possible to admit a finger into the joint. The head may or may not be tender. The motion of abduction is usually restricted, even to 30°, if the scapula is fixed. Other motions are usually maintained, but rotation may be slightly lessened. Satta believes external rotation to be weaker than normal because of the decreased inclination of the head. The head may show abnormal mobility in certain movements. The muscles of the shoulder are usually underdeveloped, especially the deltoid. The average shortening of the humerus is about 7 cm., the extremes ranging from 4 to 8 cm. In only one case was a difference in forearm length of 1 cm. present, where forearm length was measured (4 cases). A right upper dorsal curve of the spine may be present in involvement of the left shoulder, and vice versa.

The *roentgenographic picture* is a typical one. The head is in varus so that the angle of inclination which is normally 130–158° is reduced to less than 50°. The head may or may not be flattened. Its radius of curvature is lessened. There is a widening of the joint space. Both tuberosities are elevated and the greater tuberosity may be even placed at a level higher than the head. The normal greater tuberosity is placed about 6.8 mm. lower than the head. The epiphyseal line is present and is set vertically rather than horizontally. The epiphyseal line may fuse prematurely and was absent in one case at sixteen. This fusion seems to be uniform and it is uncertain whether there is a difference in the rate of growth of the upper (lateral) and lower (medial) parts of the epiphyseal line. The roentgenograms do not show an earlier fusion of the inferior part of the growth center. The anatomical neck is indistinct, marked by shallower grooving, and placed more vertically.

The special angulations of the head—the tangential angle of Preiser and the directional angle of Alsberg—are reduced. Preiser's angle is determined by drawing a line from the tip of the greater tuberosity

tangentially to the head. The angle which this line makes with a line in the course of the humerus is normally about 130°. The directional angle is normally about 48°, its extremes varying from 44 to 58°. It is calculated by the angle which a line connecting the most prominent superior and inferior points on the humeral head makes with the line of the humerus. These points are easily seen on the roentgenogram, since they are each marked by an indentation in the circumferential line of the head. This notching may be absent in humerus varus. The distance of the greater tuberosity from the caput is increased, whereas the distance from the under edge of the head to the anatomical neck is reduced.

The head tilts into varus at the thinned surgical neck. The inner cortex of the metaphysis is missing at this point and the head fits into a large groove, the wall of which is formed by the inner part of the outer cortex. No definite evidence exists which indicates that a cyst has been present at this point, nor has pathological fracture been noted there. The lateral cortex of the humerus is never expanded. The humeral shaft is in general thinned, and demonstrates a horizontal shelf at the lower part of the groove, on which the humeral head sits. The outer humeral cortex at the site of varus is not thickened, nor is it the seat of a reactive periostitis. There is an outward bowing or medial inflexion of the humerus at the level of varus in some cases. There is no observed torsion of the humerus but it has been believed that the head may be rotated anteriorly.

A localized thickening of bony trabeculae, giving increased density of bone, is seen in the oldest case. This zone of density extends from the inner humeral cortex to the humeral head in the line of the fused epiphyseal plate. It represents an end stage in healing of the trabeculae bearing maximum stress. No arthritic changes have been seen.

ETIOLOGY

Several types of humerus varus have been described. They are all characterized by a change in the angle which the head bears to the neck and shaft in the direction of varus. Secondary anatomic changes, such as high position of the tuberosities, more vertical position of the anatomic neck, etc., are consequent upon the bending of the head into varus.

Milch and Burman reported a case of simple congenital humerus varus in a girl with snapping of both scapulae. Lewin, and also Seifert, described an unusual congenital anomaly of the shoulder in which the glenoid, not now a fossa but a smooth bony projection, fitted into a foveal cavity in the humeral head, which was displaced in mild varus. Bircher and Riedinger described dystrophic forms of humerus varus in cretinism, chondrodystrophy, and rickets. This varus of the head occurs at the anatomical neck and is only a local manifestation of a general skeletal dystrophy. Wolf of Bircher's clinic noted humerus varus cretinosus in 187 of 473 roentgenograms of patients operated on for goiter, the incidence of varus being 39.5 per cent. The incidence of varus in adults over twenty-five (44 per cent) was greater than its frequency in patients under twenty-five (29.2 per cent). A study of goiter-free cases in the Ruhr district indicated complete absence of the varus deformity. These represented a mild varus, the angle of inclination being about 10° less than normal. *The association of humerus varus with coxa vara* is indicated in the reports of Turco and Rocher. In Rocher's case, a dyschondroplastic element was present. Rocher and Roudil reported a case of humerus varus on an endocrine basis in a girl of subnormal mentality.

A consideration of humerus varus on an arthritic, traumatic, inflammatory, or neoplastic cause is omitted. Milch and Burman showed a case of humerus varus in Gaucher's disease.

The roentgenograms in these cases have only one thing in common, that the humeral head is bent in varus. Otherwise, they differ, and the most bizarre appearances may be seen, especially in chondrodystrophics.

Stropeni and Nicotra believed that the rare condition which they called "humerus varus cysticus adolescentium" was a consequence of solitary cyst of the metaphyseal part of the humerus. Roentgenograms afford the only means of etiologic interpretation. There are some objections to this theory, of which the most significant one is that nobody has observed a case from beginning to end, that is, from the stage of solitary cyst to the typical humerus varus formation. In no case has the cyst or the moment of incidence of pathologic fracture through the supposed cyst been seen.

It is more likely that this condition is an end-result of an epiphyseal injury sustained at birth, or early in life. It is unfortunate that the manner of delivery is not recorded in the published cases. Delivery by breech presentation must have a significant relation to this disease. Injury by breech delivery does occur. Snedecor, Knapp and Wilson pointed out that after breech presentation the ossifying periostitis of either femur or humerus took place in the 4 cases reported by them. Their fourth case is pertinent to this discussion. The baby sustained an injury to the upper part of the left arm at time of delivery. The arm was limp and wrist drop was noted. The shoulder was painful and the area about the deltoid muscle tender and slightly swollen two to three days after delivery. Roentgenogram of the shoulder showed subperiosteal hemorrhage of the upper part of the humerus at the approximate level of the epiphyseal line. I have operated on a baby with a birth dislocation of the lower femoral epiphysis. There was extensive subperiosteal hemorrhage in this case which extended half way or more up the femoral shaft. This baby was a first baby delivered by breech presentation. Snedecor and his associates note that the pathology is a tearing or stripping of the periosteum at its weakest point of attachment, namely, at the epiphyseal line, with maximum effect usually on the proximal epiphysis of femur or humerus. All their babies were first babies and all were delivered by breech presentation. Recovery was spontaneous, they noted, within a period of a few weeks.

If there can be injury to the periosteum adjacent to the epiphyseal plate, there can be injury to the epiphyseal plate itself, without dislocation of the epiphysis. The extent of this injury cannot be accurately estimated nor the prognostic future of the growth line. In these cases of humerus varus, the medial part of the epiphyseal line was so injured that it grew at a lesser pace than its outer part. This would bring the humeral head gradually into varus. In this, it would be helped slowly by the action of the muscles attached to the greater tuberosity of the humerus, especially the supraspinatus, which would tilt the outer end of the humerus up and the inner end down.

The excavation of the humerus is due to abnormal pressure strain over a period of time. This is in accord with the law of Roux that pressure strain will cause absorption of bone. As this grooving increases, the declination of the head increases, increasing the varus, till finally a position of equilibrium is reached when the excavation is large enough for the head. The epiphyseal line becomes more vertically directed so that bone growth is less in the longitudinal axis than in the axis at right angles to the shaft, a growth strain increasing the depth of excavation of the shaft and hence the varus. This fact, plus the premature fusion of the upper humeral epiphysis, gives a very definite shortening of the humerus.

The injury to the epiphyseal plate may conceivably take place after birth, but since the development of varus of the humeral head is slowly accomplished, it must take place earlier in life rather than later. Thus, an epiphyseal plate injury after the age of ten might not develop a humerus varus of this type. The rapid growth of adolescence increases the deformity rapidly and it is then usually noted. The sudden pain in the shoulder suggestive of pathologic fracture is most probably a moment in which the humeral head sinks suddenly into more varus. The bending takes place

at the surgical neck since this is the transitional point where the cortex thins.

The uncommonness of the disease is explained by the fact that (1) it must be conditioned by injury in breech presentation; (2) it must injure the medial part of the epiphyseal line so that its rate of growth is less than the outer part and (3) it must have a long enough period of time for its development. Injury to the outer part of the epiphyseal plate should result in a humerus valgus deformity but this has not been reported. The normal tendency is for the medial part of the proximal humeral epiphysis to fuse before the lateral part.

A separation of the upper humeral epiphysis must be considered. This can occur as a birth injury, but its ordinary incidence is in the age group of adolescent humerus varus. This deformity is corrected spontaneously, as reported by Aitken, by the remodeling of the line of the humeral shaft to the head after bony organization of the subperiosteal hemorrhage on the medial side of the line.

The injury to the epiphyseal plate produces a shortening even up to 1¼ inches, but this is dependent on the age of the patient. Fusion of the epiphysis takes place between sixteen and eighteen years of age, and begins first on the medial side of the epiphyseal line. No picture of adolescent humerus varus has followed the slipping of the upper humeral epiphysis in adolescence. It is to be thought of as a cause or one of the causes of adolescent humerus varus, when the upper humeral epiphysis is displaced at birth or early in life.

Congenital thinning of the metaphysis in the region of the surgical neck of a type so advanced that it could not sustain normal weight pressure of the arm is unproved.

It is unlikely that fracture of the surgical neck of the humerus at birth or in early life is responsible for this deformity. In no case has a definite fracture been shown and in none is a history suggestive of fracture given.

No dystrophic or endocrine factors can be said to play a part, and the disease is a local one.

No biopsy or pathological specimens are available. No case has been followed to adult life; nor has any case had serial roentgenograms from incipiency to fully matured lesion.

TREATMENT

Most of these patients have been treated by physiotherapy. In the case of Anglesio (Stropeni's case), an osteotomy was done to correct the humerus varus of the head. The result in this case was good and abduction became almost complete. End-result roentgenograms were not presented. Osteotomy was the treatment recommended in this case but refused by the mother. The correction of the varus deformity alone should give increase in length; if the epiphysis is not consolidated, then its growth force longitudinally should also give added length in time. A fusion of the superior part of the epiphyseal line should also be done in this particular case.

REFERENCES

1. Aitken, A. P. End results of fractures of proximal humeral epiphysis. *J. Bone & Joint Surg.*, 1936, *18*, 1036–1041.
2. Angelotti, E. Sulla spalla vara. Atti dell' iv Cong. della Soc. Ital. Ortop., 1907; Atti dell' viii Cong. della Soc. Ital. Ortop., 1913, p. 51; *Chir. d. org. di movimento*, 1919, *3*, 513–534.
3. Anglesio, B. Osteotomia per omero varo. *Arch. di ortop.*, 1930, *46*, 417–428.
4. Bircher, E. Ueber eine der Coxa vara entsprechende Difformität der Schulter (Humerus varus) bei Kretinen. *Deutsche Ztschr. f. Chir.*, 1908, *96*, 598–617. Ein Beitrag zur Humerus varus cretinosus. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1910–1911, *16*, 325–335.
5. Ewald, P. Ueber die Arthritis deformans des Schultergelenks und die bei ihr vorkommenden Knochenverbildungen, insbesondere den Humerus varus. *Ztschr. f. orthop. Chir.*, 1911, *28*, 166–195.
6. Giovetti. Sull' omero varo. iv Cong. Ital. di Radiol. Med., 1922.
7. Haumann, W. Osteopathia cretinosa scapulae nebst einem Beitrag zum Humerus varus cretinosus. *Beitr. z. klin. Chir.*, 1927, *140*, 136–148.
8. Lange, F. Lehrbuch d. Orthopädie. Third edition, Jena, 1928, pp. 427–428.
9. Lewin, H. Seltene Missbildung des Schultergelenks. *Röntgenpraxis*, 1931, *3*, 556–560.

10. Merlini, A. L'omero varo nei microcefali e nei cretini. *Chir. d. org. di movimento*, 1922, *6*, 329–344.
11. Merlini, A. Contributo allo studio dell'acondroplasia. L'omero varo negli acondroplasici. *Radiol. med.*, 1922, *9*, 265–283.
12. Mezzari, A. Sull'omero varo inflammatorio. *Arch. di radiol.*, 1928, *4*, 100–108.
13. Milch, H., and Burman, M. S. Snapping scapula and humerus varus; report of 6 cases. *Arch. Surg.*, 1933, *26*, 570–588.
14. Nicolis, S. Contributo allo studio dell'omero varo. *Radiol. med.*, 1923, *10*, 277.
15. Nicotra, A. L'omero varo. *Clin. chir.*, 1930, *33*, 914–937.
16. Preiser, G. Ueber die praktische Bedeutung einer anatomischen und habituell-funktionellen Gelenkflächeninkongruenz. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1908, *12*, 313–322.
17. Riedinger, J. Die Varität im Schultergelenk. *Deutsches Ztschr. f. Chir.*, 1899–1900, *54*, 565. *VIII Kong. d. deutsch. Gesellsch. f. orthop. Chir.*, 1909, *3*, 317.
18. Rocher, H. L. Humérus varus double et dysplasie congénitale des deux hanches; dyschondroplasie rhizomélique. *Rev. d'orthop.*, 1933, *20*, 648–652.
19. Rocher, H. L., and Roudil, G. Un cas d'humerus varus. *Arch. franco-belges de chir.*, 1930, *32*, 524–529.
20. Rosaire, E. Contribution à l'étude de l'angle de déclinaison de l'humerus à l'état normal et à l'état pathologique. Lyon, 1892.
21. Rosenfeld. In: Lange, F., Lehrbuch d. Orthopädie. Der Humerus varus, p. 646. Jena, 1914.
22. Satta, F. Omero varo. *Chir. d. org. di movimento*, 1926–1927, *11*, 57–64.
23. Scaglietti, O. Lesioni ostetriche della spalla. *Chir. d. org. di movimento*, 1936, *22*, 183–233.
24. Seifert, E. Einige Fehlbildungen im Schultergelenk (Humerus varus—Schulterblatthochstandfragliche Geburtsverletzung). *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1931, *43*, 620–624.
25. Snedecor, S. T., Knapp, R. E., and Wilson, H. B. Traumatic ossifying periositis of newborn. *Surg., Gynec. & Obst.*, 1935, *61*, 385–387.
26. Stropeni, L. Omero varo da rottura spontanea di cisti ossea metafisaria. *Chir. d. org. di movimento*, 1928, *12*, 531–544.
27. Turco, A. Contemporaneo varismo bilaterale dell'omero e del femore. *Boll. e mem. Soc. piemontese di chir.*, 1934, *4*, 1064–1071.
28. Wolf, E. Beitrag zum Studium des Humerus Varus Cretinosus. Untersuchung der Schulterdiagramme von 500 Kropfoperierten des Kantonsspitals Aarau. *Schweiz. med. Wchschr.*, 1934, *64*, 792–794.

Vol. 40, No. 5

DIVERTICULOSIS OF THE SMALL INTESTINE

REPORT OF A CASE WITH INTESTINAL OBSTRUCTION*

By MAXIMILIAN J. HUBENY, M.D., *and* SIMON POLLACK, M.D.
CHICAGO, ILLINOIS

DIVERTICULA of the jejunum were first described by Sir Astley Cooper in 1844. His case was a male, aged sixty-five, who, on post-mortem examination, revealed multiple diverticula of the proximal portion of the small intestine. Since then numerous cases have been reported in the medical literature. Helvestine, in reporting 2 new cases in 1923, reviewed the previous literature and collected 27 cases. Levy and De Groat in 1934 reported 2 new cases and summarized the 66 proved cases from the previous literature. They also included 9 presumptive cases which had neither surgical nor post-mortem proof.

Rankin and Martin, in reviewing the cases at the Mayo Clinic, found 52 cases of small bowel diverticula (excluding duodenal and Meckel's diverticulum). Of these, 24 had single outpouchings; 18 cases were diagnosed surgically; 31 cases were diagnosed at post-mortem examination. Only 3 cases were diagnosed by roentgen examination, an incidence of 1 case per 25,000 gastrointestinal studies.

Since 1934 numerous other cases have been reported as shown in Table 1.

ETIOLOGY

The relative rarity of diverticulum formation in the small intestine as compared with the frequent observation of diverticulosis of the colon has led to numerous explanations as to the causative mechanism. The anatomical findings in almost all cases showed occurrence usually in elderly patients, over fifty years of age; the outpouchings were thinned, consisting of mucosa and serosa only, and distributed along the mesenteric border. Klebs was the first to point out that the diverticula occurred at the site of perforation of the branches of the mesenteric vessels through the muscular layers of the bowel. He thought that a locus minoris resistentiae was produced here, either by more rapid growth of the

TABLE I

Author	Year	No. Cases	Confirmed by			Remarks
			X-ray	Surgery	Post Mortem	
Guthrie and Hughes	1937	3	2	1		1 case obstructed 2 had hemorrhages
Rosedale and Lawrence	1936	4			4	All incidental findings at post mortem
Rosedale	1935	3			3	Three cases in 5,000 post mortems
Edwards	1936	12	2	3	7	
Jones and Crile	1936	4	2	2		
Machurot	1935	1		1		Torsion with intestinal obstruction
Sheppard	1935	1				
Chapman	1934	1			1	Incidental finding at post mortem

* From the Department of Roentgenology, Cook County Hospital, Chicago.

mesentery than of the blood vessels, or by undue traction at this site in the course of vigorous gastrointestinal movements. Graser as well as Hansemann felt that the weakening was due to distention of the vascular pathway through the muscle layer by venous congestion. Sudsuki explained the weakness on the basis of degenerative changes in the connective tissue of the venous adventitial layer.

Helvestine felt the locus minoris resistentiae was due to degeneration of the circular muscle fibers and to traction exerted by sclerotic vessels. Besides this, he felt that sudden changes in the intra-abdominal pressure compressed the small bowel and its contents and formed small outpouchings at the weakened points. At first the outpouchings contain all layers including muscle. With further distention they lose their "true" character and become mucous membrane pouches; the muscle tissue finally degenerates or contracts about the neck of the pouch. The common causes of increased intra-abdominal pressure are chronic cough, chronic constipation, and urinary obstruction, all of which are prevalent in persons of the older age groups.

In spite of the fact that all the above may play some part, if they were the only influencing factors then one could reasonably expect a much higher incidence of the condition. This is not found. Edwards, in a more recent pathological study of 10 cases, concludes that there are two important factors in the production of small intestinal diverticula: (*a*) The presence of an area of weakness in the bowel wall. This is almost always at the site of the vascular perforation through the muscular layers. However, one of his cases had a single diverticulum at the site of a small ectopic node of pancreas tissue in the jejunal wall. (*b*) A pulsion force to initiate and maintain the herniation. This, he explains, is due to irregular spastic contraction of the small bowel with a marked increase of the tension within the spastic segment. This concept would tend to agree with the results of Chlumsky, who studied the effects of generalized increased intra-intestinal pressure and found that, even with slowly increasing pressure, the serosa would split first, and usually on the antimesenteric side.

Chapman considers the weakness in the bowel wall predisposing to diverticulum formation to be in the connective tissue layer of the submucosa. This is normally the strongest layer and resists bursting by increased intra-intestinal pressure. However, when this tissue degenerates in older patients a locus minoris resistentiae is formed similar to the weakening of the aortic wall in luetic mesaortitis with its resultant aneurysm formation.

PATHOLOGY

The pathological findings in this condition are easily explainable in the light of the above discussed pathogenetic factors. Grossly, the sacs are multiple, thin walled, and arranged along the mesenteric border of the small bowel. The usual site is the upper jejunum. The smaller sacs are present in pairs, in relation to the mesenteric vessels which divide into two branches, a right and a left. As further distention takes place, the diverticula become bifid or bilobed; finally they completely fuse to form one large sac. More than 60 per cent of the reported cases were multiple.

Microscopically, the wall of the sac shows it to be characteristic of a "false" diverticulum. There is little or no muscle tissue except in the smaller ones; in these the muscle tissue is atrophic except for an encircling ring of muscle about the neck of the diverticulum. The lining mucosa is flattened and atrophic, and characteristic cellular infiltration may be found in the wall indicating inflammatory changes.

The presence of diverticula is by itself usually of no clinical importance, and most cases are unsuspected clinically only to be discovered as incidental findings at the post-mortem examination. However, the complications which may arise from diverticula are important and interesting, as

they are usually the cause of the patient's seeking medical aid. Among those which have been described are:

a. Inflammation—diverticulitis
b. Hemorrhage
c. Perforation—which may be a sequel of diverticulitis
d. Intestinal obstruction
e. Enterolith formation
f. Torsion

SYMPTOMATOLOGY AND DIAGNOSIS

The clinical picture in many cases of diverticulosis of the jejunum, as was mentioned above, may be symptomless and the condition remains unsuspected till post mortem. Usually, however, the uncomplicated case complains of vague gastrointestinal symptoms. Pain or epigastric distress, coming on at varying intervals after intake of food, is the commonest complaint. Sometimes the epigastric discomfort or fullness which is described has a time relationship to the intake of food. A bloated feeling, eructations, and anorexia may also be present. The history may resemble that of chronic cholecystitis except for the fact that the discomfort is usually referred to the umbilicus or to the left upper quadrant. As the usual precipitating factor for hospitalization in these cases is the development of complications, the clinical picture seen may be typical of peritonitis, or intestinal obstruction, and the underlying pathology may be entirely unsuspected.

The only clinical means available of establishing a preoperative diagnosis is by careful serial roentgenologic examination of the entire gastrointestinal tract with special study of the small bowel patterns. This was first described by Case. The usual finding is the presence of one or more round barium-filled shadows in the films of the small bowel follow-up of the upper gastrointestinal study. These shadows may remain constant for a period of hours and may show a characteristic fluid level in the upright position.

CASE REPORT

M. C., colored, female, aged sixty-three, entered the Cook County Hospital on August 31, 1937, with an examining room diagnosis of intestinal obstruction.

History. The patient entered the hospital complaining of vomiting and intermittent abdominal pain of moderate frequency and severity for the past three days. She stated that she had had similar episodes with increasing frequency for the past five to six years, but this was the worst attack.

On Saturday, August 28, she had a feeling of weakness, was "feverish" and lay down to rest. While reclining she vomited. Soon after, she noted intermittent cramp-like pains in her abdomen; these would start in the left lower quadrant and then radiate over the whole abdomen. Although these symptoms persisted she had a bowel movement that evening. The next three days these symptoms were more persistent, even though there was no complete obstipation. Intake of food or liquid exaggerated her complaints.

When the patient entered the hospital Tuesday evening, August 31, the physical examination revealed an elderly colored patient in evident discomfort and who persisted in lying on her left side for relief. Temperature was 102°F. rectally, pulse 108, respiration 24. The essential findings were abdominal. The abdomen was moderately distended and tympanitic with questionable shifting dullness in the flanks. No definite masses could be palpated. There was diffuse tenderness and slight rigidity and rebound tenderness over the whole abdomen, but these signs were much more readily elicitable over the left lower quadrant. The peristaltic sounds were diminished in frequency but occasional loud borborygmic gurgles were heard; as a rule these were coincident with the abdominal pain.

Vaginal examination was essentially negative.

Rectal examination—no feces, no blood, no masses noted.

The white blood count was 12,000, the red blood count 4,380,000, and hemoglobin 85 per cent. Urine on admission was clear, and negative for sugar or albumin. Blood Wassermann reaction was negative.

The clinical impression at the time was that the patient had a partial intestinal obstruction and that the most likely etiology was an an-

FIG. 1. The arrows indicate fluid-gas levels outside of the barium-filled colon. This was interpreted as due to partial obstruction of the small intestine. Patient upright.

nular carcinoma or a diverticulitis of the colon. However, the apparent good state of nutrition of the patient, her high red blood count and hemoglobin, and her long duration of symptoms did not seem to point to a malignant condition. She was placed on conservative management and improved clinically—becoming afebrile and unobstructed in the next two days.

On the ward, numerous observers reported palpation of a mass in the left lower quadrant, but these observations were never definite.

Gastrointestinal roentgen studies were made on September 14. The colon was quite tortuous and redundant but apparently filled well and showed no evidence of intrinsic defects. There were, however, numerous fluid-gas levels in the dilated small bowel (apparently ileum) (Fig. 1). The patient apparently began to lose ground following this examination and pain and vomiting again became manifest. In spite of supportive measures, mineral oil, parenteral fluids and enemata, the patient's response to conservative management was poor, and a laparotomy was performed by Dr. Peter Rosi on September 22. Anesthesia used was procain locally and a short period of nitrous oxide inhalation. The findings were most unusual: "Innumerable diverticula were present throughout the whole small bowel measuring from 2 to 15 cm. in diameter, located on the mesenteric side and many showed inflammatory adhesions to the serosa. One of these in the left lower quadrant, about 8 cm. in diameter, was attached to the adjacent small intestine by adhesions and produced a partial obstruction."

The obstruction was relieved, but because the condition of the patient was none too good, no further surgical procedures were carried out. The postoperative course was somewhat stormy, but the patient recovered and was up and on her feet in the ward in three weeks.

Gastrointestinal studies were carried out on October 19, 1937, using barium by mouth and the following was noted:

No unusual findings were seen in the esophagus or stomach. The duodenal bulb filled well and was of normal contour. There was a persistent globular barium-filled shadow in the

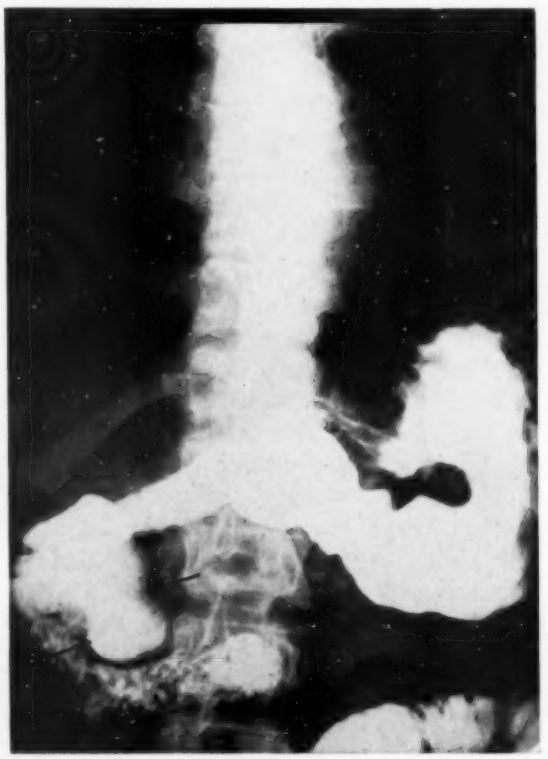


FIG. 2. The arrows indicate the large diverticulum noted in the first portion of the duodenum.

region of the second portion of the duodenum interpreted as a diverticulum (Fig. 2). Examination at intervals of one, two, five and twenty-four hours after the ingestion of the barium meal revealed numerous irregular barium-filled shadows. These were constantly noted in three areas (Figs. 3 and 4), and after twenty-four hours a fluid level was demonstrable in the vertical position. The small bowel pattern was abnormal in that the valvulae conniventes were quite prominent and the bowel lumen dilated over twice normal size. These findings were interpreted as characteristic of diverticula in the jejunum.

As an incidental finding there was an irregular mottled rarefaction and thickening of the left pelvic bone with numerous striations noted within the bone structure. From the roentgenograms a Paget's disease was suspected as an incidental finding.

A recheck examination of the upper gastrointestinal tract on November 4, 1937, revealed essentially the same findings and the patient

Fig. 3. The arrows point out three large irregular barium-filled shadows interpreted as diverticula. Note the increased width of the loop of jejunum and the prominent valvulae conniventes indicating partial intestinal obstruction.

Fig. 4. Twenty-four hours after ingestion of the barium meal. The same three diverticula are noted with fluid-gas levels demonstrable as the film was taken in the vertical position.

was discharged on November 12, 1937, apparently well.

Follow-up of the case was impossible due to inability to contact the family; however, when finally reached in January, 1938, they informed us that the patient died on December 29, 1937. No post-mortem examination was permitted.

REFERENCES

1. Boling, J. R. Multiple diverticula of jejunum with resection. *J. Am. M. Ass.*, 1931, *96*, 526.
2. Case J. T. Diverticula of small intestine other than Meckel's diverticulum. *J. Am. M. Ass.*, 1920, *75*, 1463.
3. Chapman, J. Report of case of diverticulosis of small intestine with review of recent literature. *Ann. Int. Med.*, 1934, *7*, 1376–1390.
4. Cooper, Sir Astley. Anatomy and Surgical Treatment of Abdominal Hernia. Lea & Blanchard, Philadelphia, 1844.
5. Edwards, H. C. Diverticulosis of small intestine. *Ann. Surg.*, 1936, *103*, 230–254.
6. Gordinier, H. C., and Sampson, J. A. Diverticulitis (not Meckel's) causing intestinal obstruction; multiple mesenteric diverticula of

small intestine. *J. Am. M. Ass.*, 1906, *46*, 1585–1590.
7. GRASER. Quoted by Helvestine, ref. 10.
8. GUTHRIE, D., and HUGHES, F. A., JR. Diverticulosis of small intestine; report of 3 cases. *Surgery*, 1937, *1*, 595–609.
9. HANSEMANN. Quoted by Helvestine, ref. 10.
10. HELVESTINE, F., JR. False diverticula of jejunum. *Surg., Gynec. & Obst.*, 1923, *37*, 1–5.
11. JONES, T. J., and CRILE, G., JR. Diverticula of jejunum; report of 4 cases. *Am. J. Digest. Dis. & Nutrition*, 1936, *3*, 120–122.
12. KLEBS. Quoted by Helvestine, ref. 10.
13. LEVY, J. S., and DE GROAT, A. F. Diverticula of jejunum; review of literature and report of 2 new cases. *Am. J. Digest. Dis. & Nutrition*, 1934, *1*, 708–713.
14. MACHUROT, M. Axial torsion and volvulus of small intestine due to large diverticulum. *J. de chir. et ann. Soc. belge de chir.*, 1935, *34-32*, 242–244.
15. RANKIN, F. W., and MARTIN, W. J., JR. Diverticula of small bowel. *Ann. Surg.*, 1934, *100*, 1123–1135.
16. ROSEDALE, R. S. Jejunal diverticulosis. *Surg., Gynec. & Obst.*, 1935, *61*, 223–228.
17. ROSEDALE, R. S., and LAWRENCE, H. R. Jejunal diverticulosis. *Am. J. Surg.*, 1936, *34*, 369–373.
18. SHEPPARD, C. L. E. L. Jejunal diverticulosis, with report of case. *New Zealand M. J.*, 1935, *34*, 329.
19. SUDSUKI. Quoted by Helvestine, ref. 10.
20. WATSON, C. M. Diverticula of jejunum; case with enterolith causing intestinal obstruction. *Surg., Gynec. & Obst.*, 1924, *38*, 67–71.

Vol. 40, No. 5

EXPERIMENTAL STUDIES ON GASTRIC PHYSIOLOGY IN MAN

VI. THE RELATION OF SIZE, SHAPE AND POSITION OF THE STOMACH TO ITS ACID SECRETION

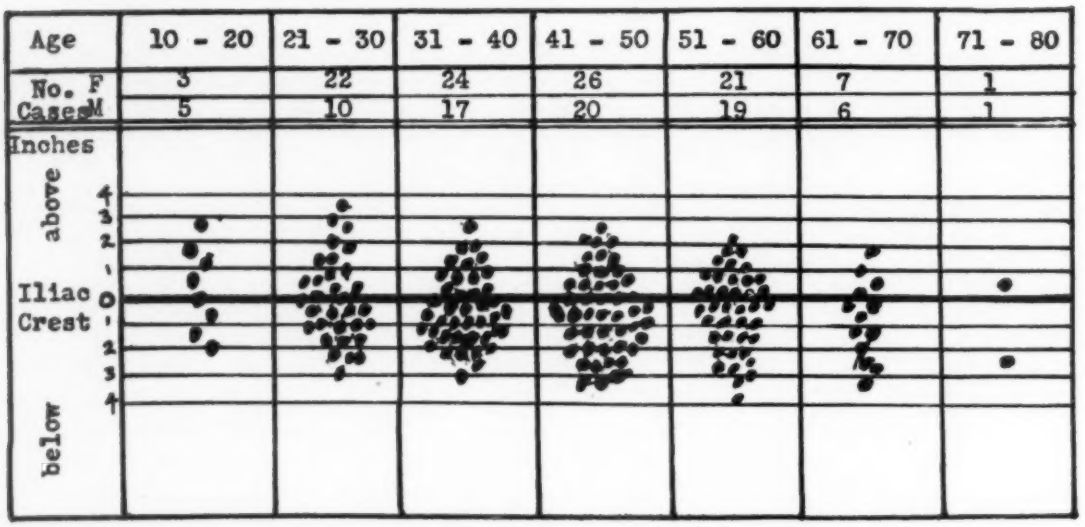
AN ANALYSIS OF POSTURE, HABITUS, HEIGHT AND WEIGHT AS INFLUENCING FACTORS ON GASTRIC FORM, SECRETION AND MOTILITY

By J. GERSHON-COHEN, M.D., HARRY SHAY, M.D., *and* SAMUEL S. FELS
PHILADELPHIA, PENNSYLVANIA

IN conjunction with our studies on the relationship of gastric emptying and the secretion of hydrochloric acid, the question was raised of the possible relationship of the size, shape and position of the stomach to its acid secretory activity. So little reference is made to acid secretory disturbances in the quadrupeds that one of us was again prompted to ask whether abnormal acid secretory response in the human might not be one of the penalties man pays for the assumption of the erect position. Could the form of the stomach, as considered by Schlesinger,[11] especially the level of the pylorus with relation to that of the lower pole of the stomach, be a determinant factor in gastric acid response? If the mixture of the pyloric gland secretions with the *fundic* gland secretions is necessary, which is one of the possible requisites suggested by the development of achlorhydria after resection of the pyloric segment, then the question of the shape of the stomach might be very pertinent. Certainly the high incidence of achlorhydria after resection of the pyloric portion of the stomach, even though normal acid was secreted before the operation, lends color to the secretion or stimulation from the pyloric segment as a possible important factor in the formation of hydrochloric acid. If the form of the stomach were J-shaped and the pylorus high due to a long vertical antrum, then possibly the secretion of the pyloric glands would more readily drop back into the body and fundus of the stomach completing the necessary mixture with the "acid" secretions of the fundic glands resulting finally in the formation of hydrochloric acid. Such a possible mechanism might be suggested if the J-shaped stomach were found to be more consistently normal or higher in its acid response than the steer horn form where the pylorus is the lowest portion of the stomach. Pursuant to the same reasoning, possible differences in gastric acid response were sought under standard conditions with subjects in the erect and recumbent positions. These examinations were extended farther to determine what relation existed between height, weight, age, sex, habitus, posture, abdominal wall tension and gastric size, shape, position, acid response and emptying time. Habitus and posture were appraised not only by direct physical examination, but from study of photographs and roentgenograms taken of the anterior and lateral aspects. In some cases, roentgen examinations of the stomach were made with the patient in the supine, prone, Trendelenburg, right and left recumbent positions for the effect of these positions on the size, shape, position and emptying time. The acid secretory response was measured after an Ewald test meal. The roentgen test meal consisted of 2 ounces of barium sulphate suspended in 250 cc. of water near body temperature. Since this meal is half the usual quantity employed and was free from the addition of such motor influencing substances as buttermilk, milk, chocolate or other flavoring ingredients, care must be exercised in analyzing our results with those of others as they relate to the position of the lower pole of the stomach and the emptying time, determined roentgenographically

TABLE I

POSITION OF STOMACH IN 182 CASES (104 FEMALES—78 MALES)



(Tables I, II, and III). In plotting the position of the lower border of the stomach in relation to the level of the iliac crests, it would seem that with increasing age there is a tendency to a descent of the gastric fundus and that this tendency is slightly greater in the female.

These studies were made on 182 normal subjects; of these, only 108 had determinations made of their gastric acid response, 75 falling within average or normal range, 17 within hyperchlorhydric and 16 within achlorhydric ranges (Table IV). The incidence of abnormal acid secretory response was not materially different in the sexes (Tables V and VI). The height and weight of all subjects was compared with the weight expected for the age and height of the individual according to standard tables (Dr. O. T. Wood, Child Health Organization). Of the 104 females, 72 were found to have weights within 10 per cent of that expected

TABLE II

POSITION OF STOMACH IN 104 FEMALES

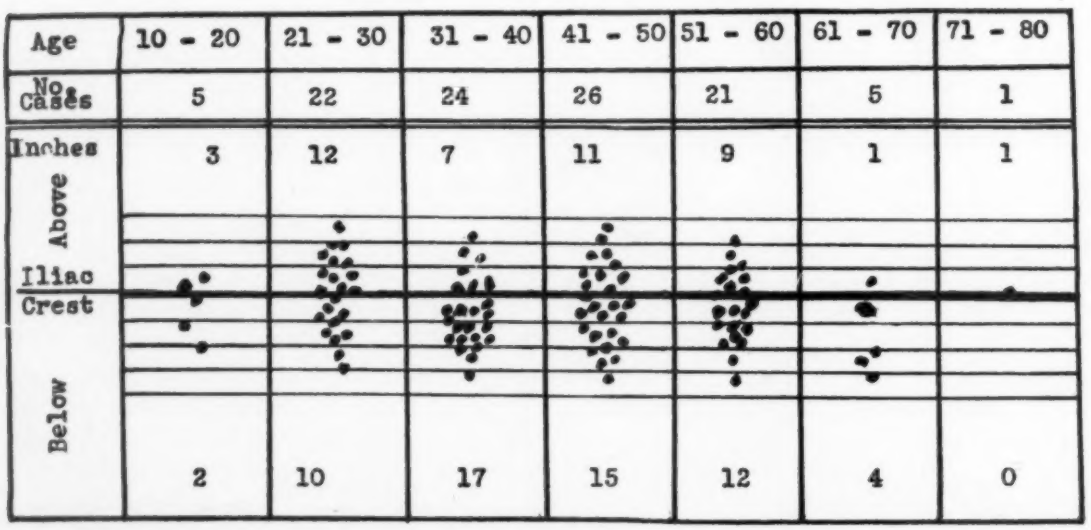


TABLE III

POSITION OF STOMACH IN 78 MALES

Age	10 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
No. Cases	3	10	17	22	19	6	1
Inches above Iliac Crest	2	4	8	11	8	3	0
below	1	6	9	11	11	3	1

TABLE IV

GASTRIC ACID SECRETIONS IN 108 SUBJECTS

Age	10-20	21-30	31-40	41-50	51-60	61-70	71-80
No. Cases	3	17	24	32	26	6	0
Hyperchlorhydria							
Normal Acid							
Achlorhydria							

TABLE V

GASTRIC ACID SECRETIONS IN 47 MALES

Age	10-20	20-30	30-40	40-50	50-60	60-70
Cases	2	7	11	13	12	2
Hyper						
Acid Normal						
Acid Anacid						

TABLE VI

GASTRIC ACID SECRETIONS IN 61 FEMALES

Age	10-20	20-30	30-40	40-50	50-60	60-70
Cases	1	10	13	19	14	4
Hyper						
Acid Normal						
Acid Anacid						

for their age and height, 14 were lower and 18 were higher than this normal variation. Of the 78 males, 47 were found to have weights within 10 per cent of that normal for their age and height, 10 were lower and 21 were higher.

Anteroposterior and lateral photographs were taken of 104 of the 182 subjects so that this kind of record, the *sine qua non* of determining habitus insisted upon by Mills,[8] was available in correlating position of stomach and habitus. There is little doubt that these pictorial records are illuminating and made relative measurements easier between given anatomical landmarks of the body and the stomach. The roentgenograms, however, were found equally useful when made especially for measurements of habitus and posture. The intercostal angle was recorded roentgenographically at the time of the stomach examination by bending a thin lead wire at the intercostal angle so that it followed the course of the lowest rib on either side (Fig. 1). We followed Carman[2] in our criteria of habitus classification.

(a) In the *hypersthenic group* were placed those individuals with robust broad frames, great musculature and weight, short broad deep thorax, long anterior abdominal wall, the intercostal angle 90 degrees or more with the ribs elevated toward a horizontal position, the lower thorax wide and deep and the heart oblique or nearly transverse. These subjects were frequently more than 10 per cent heavier than the weight normally expected for their height and age.

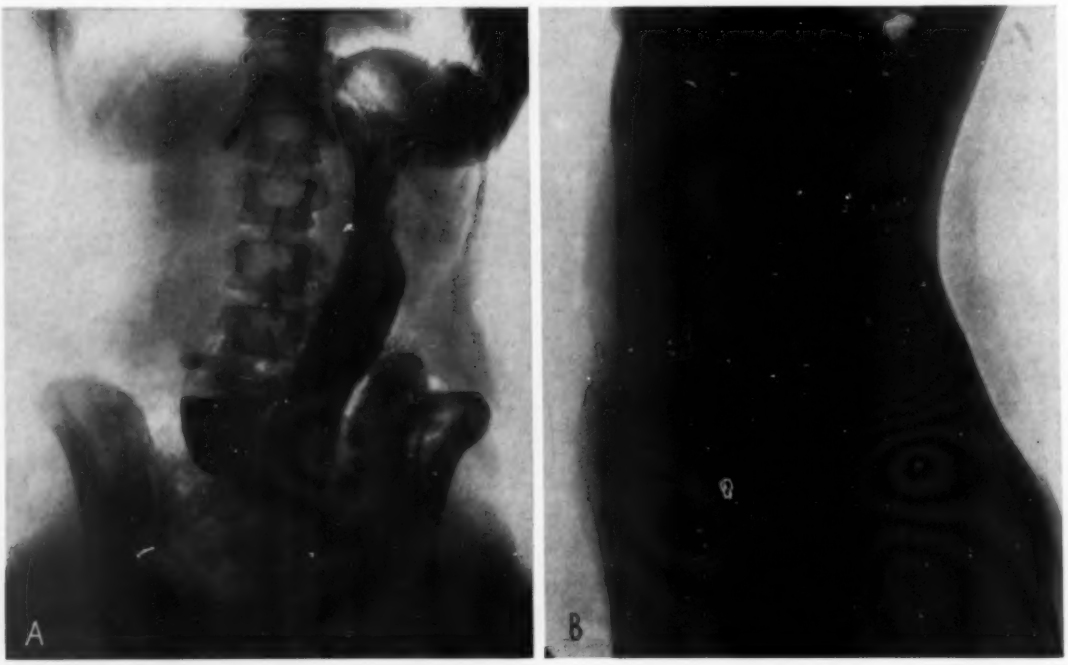


FIG. 1

(b) In the *asthenic group* were placed those of slight build, with a long narrow flat thorax, the ribs quite oblique, the intercostal angle about 75 degrees or less, the abdomen short and of weak musculature. The upper thorax was frequently very capacious and extended well above the clavicles, the heart vertical, narrow and centrally placed.

(c) Into the *sthenic* class went those subjects not hypersthenic or asthenic.

In attempting to use photographs for analysis of posture, the roentgenograms of the same patient showed how a serious

error could occasionally occur in appraising lateral silhouette postural changes. In several instances, considerable lordosis was definitely exhibited in the lateral roentgenograms of stout individuals whose posterior contour was quite straight in the lumbosacral area as viewed in the photograph of the lateral aspect. These findings suggest that the relatively uncommon finding of faulty bodily mechanics in many sthenics studied by Carnett and Bates[3] might be more apparent than real; that in some of these cases, the heavier musculature compensated adequately for slight malalignments of the spinal column not appreciated by simple inspection of the patient himself or of his photographic silhouette.

Table VII

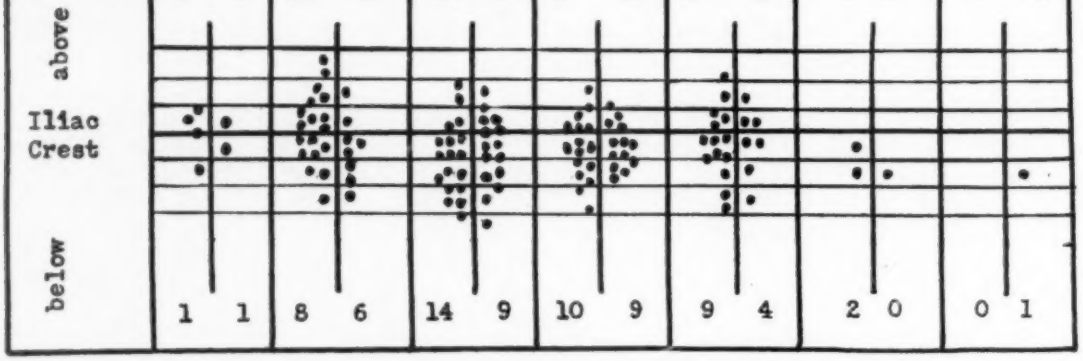
Incidence of Habitus			Sex				Relation of Stomach to Habitus and Weight-Height Ratio				
Habitus	Number and Percentage According to Habitus		Male		Female		Number and Percentage in Which Position of Stomach Corresponds to Habitus		Number and Percentage in Which Position of Stomach Corresponds to Weight-Height Ratio		
Hypersthenic	19	11%	16	84%	3	16%	17	89%	17	89%	Weight more than 10% height
Sthenic	139	76%	52	37%	87	13%	114	82%	122	87%	Weight within 10% for height
Asthenic	24	13%	10	40%	14	60%	22	92%	21	90%	Weight more than 10% less than normal for height
Total	182	100%	78		104						

The relation of stomach position with habitus was quite consistent in the hypersthenics and asthenics, as pointed out by Mills,[8] but in the intermediate group, the relationship was not so constant. The weight factor seems more regularly associated with gastric position than the factor of habitus. Of the 19 hypersthenics, 17 were more than 10 per cent above their expected weight for their height, and of the 24 asthenics, 21 were more than 10 per cent less than their expected weight for their height. Of the 19 hypersthenics, 16 were men and of the 24 asthenics, 14 were women, a sex incidence similar to that found by Mills (Tables VII, VIII, IX, X, and XI). The relation of gastric position to height-weight ratios was more constant than to habitus estimates. When one subject, a woman aged forty-six, of sthenic habitus, 5 feet, 2 inches in height, weighing 78 pounds instead of 108 pounds, the expected normal for her height, presented a high-placed stomach, we were inclined to suspect a pathological state, even though there was a normal relationship between her habitus and the position of her stomach. Later, a carcinoma of the left ovary was found and at operation widespread peritoneal metastasis was present which so filled the abdomen as to elevate the stomach, the lower border of which was about 1 inch above the iliac crests with the patient in the erect position. This case called our attention to the fact that if the position of the stomach is not commen-

TABLE VIII

POSITION OF STOMACH IN 72 FEMALES AND 47 MALES WHOSE WEIGHT WAS WITHIN 10 PER CENT OF NORMAL FOR THEIR HEIGHT AND AGE

Age		10-20	21-30	31-40	41-50	51-60	61-70	71-80
Cases	F	4	18	18	16	14	2	0
	M	2	8	16	13	7	1	1
Inches above Iliac Crest		3 1	10 2	4 6	6 4	5 3	0 1	0 0
Inches below Iliac Crest		1 1	8 6	14 9	10 9	9 4	2 0	0 1



surate with the height-weight ratio, suspicion can be entertained of a pathological process, even if the gastric position coincides with that expected from estimates of habitus. The following case also demonstrated how the height-weight ratio is sometimes found to be more accurate than habitus as a gastric position index in those patients below normal weight by more than 10 per cent In Figure 1, this subject, a female aged thirty-two, who weighed 110 pounds, 36 pounds below that normal for her height (5 feet, 6 inches), the lower border of the stomach was 4 inches below the level of the iliac crest when she was in the erect position. Being of a sthenic habitus, the lower border is considerably lower than would be expected for this

TABLE IX

POSITION OF STOMACH IN 18 FEMALES AND 21 MALES WHOSE WEIGHT EXCEEDED BY MORE THAN 10 PER CENT THAT OF NORMAL FOR THEIR HEIGHT AND AGE

Age		10-20	21-30	31-40	41-50	51-60	61-70	71-80
Cases	F	0	2	4	6	5	1	0
	M	1	2	1	6	9	2	0
Inches above Iliac Crest								
Inches below Iliac Crest								

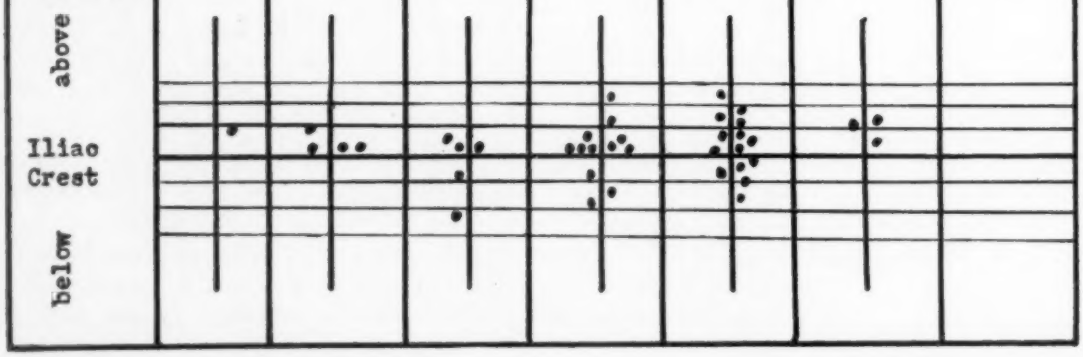
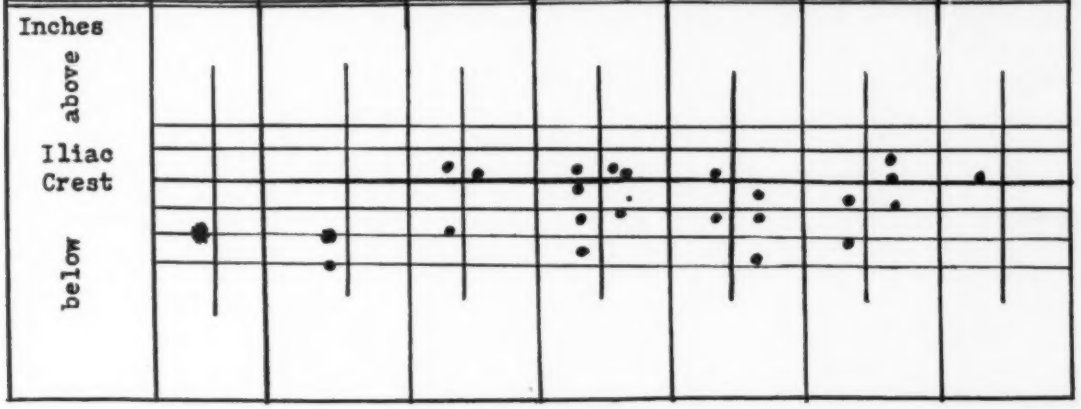


Table X

POSITION OF STOMACH IN 14 FEMALES AND 10 MALES WHOSE WEIGHT WAS LESS BY MORE THAN 10 PER CENT OF NORMAL FOR THEIR HEIGHT AND AGE

Age		10-20	21-30	31-40	41-50	51-60	61-70	71-80
Cases	F	1	2	2	4	2	2	1
	M	0	0	1	3	3	3	0



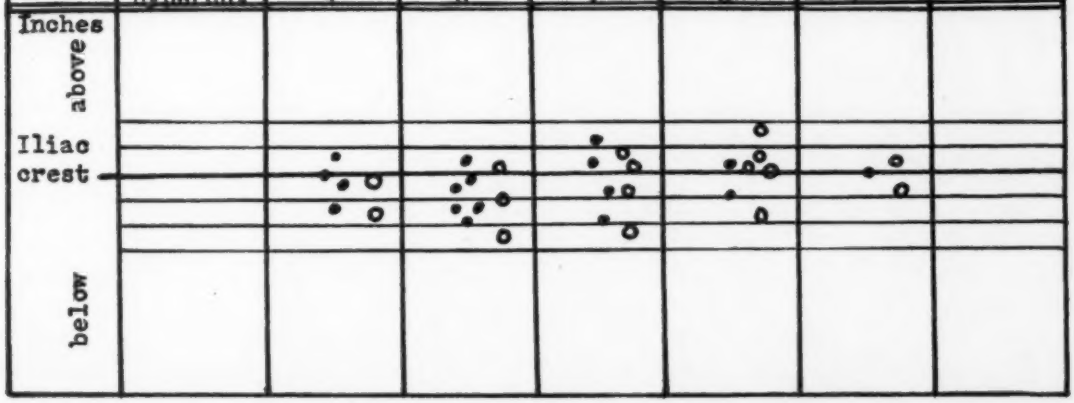
habitus, but is actually where it would be expected with her weight-height ratio. The relationship of height-weight ratio to gastric position warrants more study, and this consideration by Bedingfield[1] might have been of some real value in explaining many of his inconsistent relationships between habitus and chronic intestinal invalidism, a subject so completely studied by him.

A tense abdominal wall is naturally associated with hypersthenics and conversely a loose, flabby, thin abdominal wall is regarded as commonly observed in the asthenic. Tension of the anterior abdominal wall would therefore seem to have an important bearing on the positions of the abdominal viscera. Although this is probably true, it must also be remembered that anterior wall tension is related to the weight-height ratio and particularly to the fullness of the abdominal cavity so typi-

Table XI

POSITION OF HYPERCHLORHYDRIC (●) AND ACHLORHYDRIC (○) STOMACHS

Age		10 - 20	21 - 30	31 - 40	41 - 50	51 - 60	61 - 70	71 - 80
No. Cases	Achlor.		2	3	4	5	2	
	Hyperch.		4	6	4	2	1	



cally demonstrated in pregnancy, ascites, intra-abdominal tumors, etc. But tense and taut anterior abdominal walls, encountered in asthenics or sthenics, even athletes, as demonstrated by Chamberlain, Moody and Van Nuys[4] and Moody[9] might be found where the stomach is low, especially when the subject's weight is below that expected for his height.

Tone and position of the other abdominal viscera also have some bearing on the position of the stomach; particularly is this true of the transverse colon which sometimes causes cascading and elevation of the stomach. These considerations are not part of this report.

The form of the stomach was classified into the two large general groups, the steer horn form and the fish hook or J-form. Of the 182 subjects, 10 females and 14 males had steer horn shaped stomachs; of these 24 cases, 11 were achlorhydric while of the 158 instances of J-shaped stomachs only 5 were achlorhydric. It is interesting to note that only one steer horn stomach was found to be hyperchlorhydric, while the remaining 16 hyperchlorhydric stomachs were J-shaped, some very much fish hooked. Although Haudek[6] made similar observations in 1913, these findings seem quite contrary to those believed generally, namely, that hyperchlorhydria is usually associated with the steer horn form of stomach. These findings may have more significance than at first would be apparent. It is possible that in the J-shaped stomach with a marked "hubhöhe" of the antrum, there is a better arrangement for a mixture of the pyloric gland with those of the fundic gland secretions resulting in a better acid response than when these pyloric gland secretions, which are poured more easily through the dependent pylorus of a steer horn stomach, fail to come into mixture with the secretions of the higher placed fundic glands; or possibly the mechanism is one whereby the alkaline mucoid secretions of the pyloric glands, coming into contact with the duodenal mucosa before the other contents after leaving the steer horn stomach, so obtund the reflex stimulus to gastric secretions that a low gastric acid secretion with rapid gastric emptying follows as a consequence. Thus the relation of the form of the stomach to its acid response might well receive more intensive study where an opportunity is afforded to correlate these findings in a large number of cases!

With the test meal used by us during the roentgen studies, consisting of 2 ounces of barium sulphate dissolved in 250 cc. of water, *two hours* was found the limit of normal gastric evacuation time. We did not regard a small residue of 10–15 per cent at the end of this period as significant. Experience from numerous observations convinced us of the reliability of this viewpoint. If roentgenoscopic observations are made at fifteen-minute intervals, it is surprising how variably gastric evacuation actually occurs. It may be continuous or intermittent during part or all of the period of gastric emptying and change from one to the other type at very different intervals. Stomachs with normal acid response usually evacuate at short intermittent intervals so that a 250 cc. water barium meal is emptied in one to one and one-half hours; if there is some excessive mucus present, or the antrum is long and vertical as in the J-shaped forms, a 10–15 per cent residue may be seen after sixty to ninety minutes which may remain in the stomach for another hour or two before being finally evacuated. These "terminal residues" can be very misleading and doubtless account for the lively discussions so frequently encountered in questions of gastric motility as determined roentgenographically. Both achlorhydria and hyperchlorhydria seemed to be associated with rapid gastric evacuation, although emptying was generally faster in the achlorhydric and steer horn form of stomach than in the hyperchlorhydric and J-shaped stomach. The matter of pyloric control and its relationship to gastric evacuation has been previously reviewed by us and must be borne in mind here as one of the cardinal mechanisms to

be considered in this question of gastric emptying time.[10]

The positions of the patient, in the absence of abnormal anatomical defects or pathological changes, seemed to have no effect on gastric evacuation. Putting the subject into the Trendelenburg position, prone, supine or in either lateral recumbent position had no appreciable final effect in changing either the acid secretory response or evacuation time of the roentgen barium water meal. Notice that we say "final effect" and by this we mean that the *final evacuation time* of the gastric contents with a given subject was not altered by change in the position of the patient during the observation period. Differences in the "rhythm," sometimes marked, did occur with changes in position. For instance, one change frequently noted was rapid emptying that occurred for a short time following change of the position of the patient from the left lateral recumbent to the right lateral recumbent position; or from the supine to the prone position; or from the Trendelenburg to the erect position; but this initial rapid emptying which ensued on these changes usually was followed by a compensating long period of cessation of gastric emptying like the period of rest that follows cardiac extrasystoles. Other changes were also sometimes observed; whereas with the patient in the erect position, peristalsis might be hardly visible and evacuation practically in abeyance, with the patient placed in either the prone or right lateral recumbent position, peristalsis might seem to become more active and gastric evacuation more rapid for a short time; with the patient in the supine, left lateral recumbent or in the Trendelenburg position, the antrum might seem empty, gastric peristalsis and motility apparently absent, but if observations were continued, emptying of the stomach was found actually occurring but determined only by noting the diminution in the amount of gastric contents and the corresponding increase in the intestinal contents. This all takes place in spite of some difficulty in seeing the actual emptying as it occurs through the pylorus. Finally, the stomach is empty almost in the same period as when the patient was in the erect position.

Our experience with gastric analyses conformed with the roentgen observations on motility. No matter in what position the subject was placed, the gastric acid response was essentially the same to the same test meal, varying only slightly at each fractional determination.

SUMMARY

The normal stomach has a wide range of position in the normal subject. Its position and form seem conditioned principally on habitus, weight, posture and fullness of the abdominal cavity. The lower border of the stomach has a tendency to become lower with increasing age and probably to a greater degree in females. Achlorhydria seems to be more commonly associated with the steer horn shape of stomach in which evacuation occurs more rapidly than normal. Hyperchlorhydria tends to be more usually associated with the J-shaped stomach and with more rapid motility than with normal acid response in a J-shaped stomach. There seems to be a progressive increase in the number of achlorhydrics and hyperchlorhydrics with increasing age and achlorhydria tends to appear later than hyperchlorhydria. In a cross section of all ages, almost 15 per cent were found to be achlorhydric and 10 per cent hyperchlorhydric. No significant sex difference was found in this respect, although in the fourth and fifth decades, women with achlorhydria seemed to predominate, while in the two succeeding decades, men predominated. Hyperchlorhydria seemed to occur most frequently in the third and fourth decades, and earlier in men than in women.

The higher the stomach and the more inclined to the steer horn form, the more likely was the habitus to be sthenic and the subject overweight.

Achlorhydria was found more frequently associated with the steer horn shaped than

with the J-shaped stomach and this association warrants more intensive study in seeking an explanation for the determinants of gastric acid response, the action of the pylorus and gastric emptying time.

The position of the patient did not materially affect either the gastric acid response or the emptying time of a given test meal.

REFERENCES

1. BEDINGFIELD, H. A review of visceroptosis and allied abdominal conditions associated with chronic invalidism. Part II. *Quart. J. Med.*, 1929–1930, *23*, 1–65.
2. CARMAN, R. D. The Roentgen Diagnosis of Diseases of the Alimentary Canal. Second edition. W. B. Saunders Co., Philadelphia, 1920, pp. 94–134.
3. CARNETT, J. B., and BATES, W. Bodily mechanics in relation to ptosis of abdominal organs and to abdominal pain and tenderness. *Physiotherapy Rev.*, 1932, *12*, 246–249.
4. CHAMBERLAIN, W. E., MOODY, R. O., and VAN NUYS, R. G. Position of stomach, liver and colon; results of roentgenologic study of 600 healthy adults. *J. Am. M. Ass.*, 1923, *81*, 1924–1931.
5. CONRAN, P. C. On dropping of the stomach; study based on 150 cases. *Quart. J. Med.*, 1921–1922, *15*, 144–166.
6. HAUDEK, M. Ueber die radiologische Prüfung der Magenmotilität und ihre Resultate. *Fortschr. a. d. Geb. d. Röntgenstrahlen*, 1914, *21*, 472–479.
7. MILLS, R. W. The x-ray test of gastric motility. *Tr. Am. Gastro-Enterol. Assn.*, 1918, 36–47.
8. MILLS, R. W. Two tables pertaining to the incidence of bodily habitus and time of complete gastric motility in different types of habitus. AM. J. ROENTGENOL., 1922, *9*, 731–734.
9. MOODY, R. O. Position of abdominal viscera in healthy young British and American adults. *J. Anat.*, 1927, *61*, 223–231.
10. SHAY, H., and GERSHON-COHEN, J. Experimental studies in gastric physiology in man. II. A study of pyloric control; rôles of acid and alkali. *Surg., Gynec. & Obst.*, 1934, *58*, 935–955.
11. SCHLESINGER, E. Weitere Aufschlüsse über den Befund und die Genese der Gastroptose durch das Röntgenbild. *Deutsches Arch. f. klin. Med.*, 1912, *107*, 552–572.

Vol. 40, No. 5

BARIUM SULPHATE SUSPENSION IN COLLOIDAL ALUMINUM HYDROXIDE

AN IMPROVED CONTRAST MEDIUM FOR THE ROENTGENOGRAPHIC DIAGNOSIS OF GASTROINTESTINAL LESIONS*

By EDWARD E. WOLDMAN, M.D.*
CLEVELAND, OHIO

IN RECENT years, the condition of the gastric mucosa in gastrointestinal diseases has received more and more attention, and its significance in the diagnosis and treatment of these conditions has been more fully appreciated. Numerous examinations, including gastroscopy, have been recommended for studying the mucous membrane, but most physicians still depend on roentgenologic visualization of the stomach and duodenum, with barium as the contrast medium, for information concerning the condition of the mucosa of the digestive tract.

The substance which has always been employed for this purpose, a mixture of barium sulphate in water, has certain disadvantages, and does not always produce satisfactory results. The barium has a tendency to precipitate almost immediately (Fig. 1) and hence in small quantities often produces an irregular, spotty shadow on the roentgenogram, with no clear delineation of the rugae of the gastric mucosa. To visualize the mucosal folds of the stomach satisfactorily, compression and considerable manipulation are usually necessary.

For these reasons, an improved contrast medium for roentgenography of the gastrointestinal tract is desirable. Such a preparation, to fulfill the requirements of its function in an optimum manner, should be a smooth, liquid, radiopaque suspension, from which precipitation will not occur, fluid enough to enter all the recesses homogeneously, and yet viscid and tenacious enough so that a small quantity will adhere to the walls of the membrane. These properties should make possible a clear delineation of the contour of the gastrointestinal tract with the pattern of its mucosal folds depicted in detail on the roentgenogram.

Since studying the effects of colloidal aluminum hydroxide in the treatment of patients with peptic ulcers, it occurred to me that this might be mixed with barium to yield the properties desirable in a medium for gastrointestinal reontgenography.

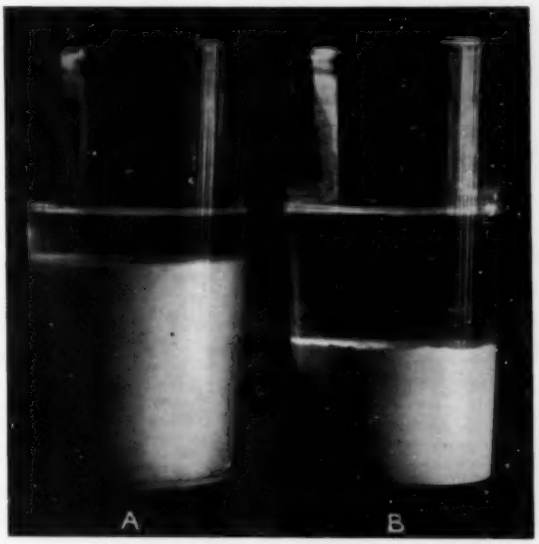


FIG. 1. *A*, barium-water mixture after standing one-half hour; *B*, barium-water mixture after standing six hours.

Numerous investigators, including Ivy and his collaborators,[2] have reported that in animals receiving preparations of aluminum hydroxide, necropsy frequently shows the mucosa of the stomach and duodenum coated with the material so that it appears as if covered with flour paste or flaky curds. Clinical experience has proved that this preparation is non-toxic and has no harmful effects, even in large doses. I have treated a large number of patients with peptic ulcer by means of aluminum hydrox-

* From the Department of Gastroenterology, Division of Medicine, St. Luke's Hospital, Cleveland, Ohio.

Fig. 2. *C*, barium sulphate-aluminum hydroxide suspension after standing six hours; *D*, barium sulphate-aluminum hydroxide suspension after standing forty-eight hours.

ide, with a continuous drip into the stomach, administering about 1,200 cc. of 25 per cent solution daily, for ten days.[4,5,6] In 2 instances, because of an air leak in the apparatus controlling the drops, which was accidentally overlooked, 1,000 cc. or more flowed into the stomach within an hour, with no ill effects. Laboratory studies on animals have proved that there is practically no absorption of ingested aluminum.[3] Einsel, Adams and Myers[1] confirmed this by clinical studies in the treatment of peptic ulcer, and also showed that large doses of aluminum hydroxide do not disturb the acid-base equilibrium, as proved by estimations of the chlorides and carbon dioxide-combining power of the blood. Colloidal aluminum hydroxide contains only 5 per cent aluminum hydroxide and about 0.6 per cent sodium chloride; the remainder, or 94.4 per cent, is water. It is mildly astringent, nonirritating and amphoteric, with a pH of 6.9, and hence its administration presents no hazard of alkalosis.

Knowing these certain facts about colloidal aluminum hydroxide, namely, that it forms a thin coating on the mucous membranes of the digestive tract, that it is nontoxic, and that its colloidal character is not disturbed by dilution with water, it seemed likely that, when mixed with barium, it would prove to be an ideal contrast medium for roentgenography, provided it would hold the barium in suspension. To test this, 60 grams or 2 ounces of barium sulphate was added to 7 ounces of a mixture of equal parts of colloidal aluminum hydroxide and water, and allowed to stand in a glass. The barium remained in suspension for twenty-four hours, and then there was a slight sedimentation, leaving about 0.5 cm. of clear water at the top. It remained at this level indefinitely. Figure 2, *C* and *D*, shows the barium sulphate-aluminum hydroxide suspension after six hours and after forty-eight hours. This forms a striking contrast with Figure 1, which shows the amount of precipitation of the ordinary mixture of barium and water after half an hour and after six hours.

The colloidal aluminum hydroxide-barium sulphate suspension is viscid and tends to adhere to the glass much more readily than the ordinary barium mixture. This is shown also when the patient drinks the

Fig. 3. Roentgenogram of the stomach made after ingestion of the barium-aluminum suspension by mouth, and without the aid of compression or manipulation. Note the normal gastric rugae.

liquid, because the entire mucous membrane of the mouth and tongue becomes coated with the suspension.

Because the barium remains in suspension, it can be used in smaller quantities, and it yields a much better outline of the stomach and intestines on the roentgenogram than is possible with a barium-water mixture. The roentgenogram of the stomach shown in Figure 3 was made without any compression or manipulation. In the roentgenogram of the colon (Fig. 4) the contrast medium was administered by mouth, and yields detail of the longitudinal folds. The proportion of barium sulphate to aluminum hydroxide used to make these roentgenograms was that already mentioned, 60 grams to 7 ounces of a 50 per cent mixture of colloidal aluminum hydroxide. If a thicker mixture is desired, more aluminum hydroxide can be added, without increasing the quantity of barium. This makes the suspension much lighter than if more barium is added, and precludes the dangers of caking of large quantities of barium in the lower intestines, with the attendant discomfort and the potential hazard of impaction in the rectum.

Fig. 4. Roentgenogram of the colon made after ingestion of the barium-aluminum suspension by mouth. Note the longitudinal folds of the intestine.

SUMMARY

Barium sulphate suspended in colloidal aluminum hydroxide is recommended for roentgenographic examination of the gastrointestinal tract as having advantages over the barium-water mixture now generally employed. Because of the colloidal nature of the aluminum hydroxide, the barium is held in suspension, and hence can be used in smaller quantities. In these studies, 60 grams of barium sulphate was added to 7 ounces of a mixture of equal parts of colloidal aluminum hydroxide and water, to form the contrast substance.

The preparation is fluid so that it enters all the recesses in a homogeneous manner, and yet viscid and tenacious so that a small quantity coats the wall of the digestive tract, and yields a satisfactory roentgenographic visualization of the mucosal folds. The barium sulphate-aluminum hydroxide suspension is non-toxic, and does not alter the acid-base equilibrium of the blood. The addition of aluminum hydroxide to the barium mixture does not render it less palatable.

REFERENCES

1. Einsel, I. H., Adams, W. L., and Myers, V. C. Aluminum hydroxide in treatment of peptic ulcer. *Am. J. Digest. Dis. & Nutrition*, 1934, *1*, 513–516.
2. Ivy, A. C., Terry, L., Fauley, G. B., and Bradley, W. B. Effect of administration of aluminum preparations on secretory activity and gastric acidity of normal stomach. *Am. J. Digest. Dis. & Nutrition*, 1937, *3*, 879–883.
3. Myers, V. C., and Morrison, D. B. Influence of administration of aluminum upon aluminum content of tissues of the dog. *J. Biol. Chem.*, 1928, *78*, 615–624.
4. Woldman, E. E., and Rowland, V. C. A new technique for the continuous control of acidity in peptic ulcer by aluminum hydroxide drip. *Am. J. Digest. Dis. & Nutrition*, 1936, *2*, 733–736.
5. Woldman, E. E., and Rowland, V. C. Continuous acid adsorption by aluminum hydroxide drip in treatment of peptic ulcer. *Rev. Gastroenterol.*, 1936, *3*, 27–35.
6. Woldman, E. E. Treatment of hematemesis and melena by a continuous aluminum hydroxide drip. *Am. J. M. Sc.*, 1937, *194*, 333–340.

RADIATION TREATMENT OF PANCREATIC CANCER

By GEORGE T. PACK *and* GORDON McNEER
The Memorial Hospital for Cancer and Allied Diseases
NEW YORK, NEW YORK

CANCER of the pancreas has long been considered a hopeless disease. Although many attempts at surgical extirpation have been made, only a few surgeons have been bold and skillful enough to perform partial pancreatectomy for carcinoma. The attempts of most surgeons have been directed at the palliative procedure of cholecyst- or choledocho-enterostomy. It is not within the scope of this discussion to analyze the benefits of such procedures too extensively. Yet if one has a supplementary or complementary form of treatment to offer, a very brief excursion is warranted.

APPRAISAL OF PALLIATIVE SURGERY

Judd and Hoerner analyzed the end-results of 158 cancers of the pancreas treated by palliative surgical procedures at The Mayo Clinic prior to 1935. Ninety-four patients with diagnosis proved by biopsy survived for an average period of 10.2 months. Only 4 per cent of all patients experienced no palliation or relief of symptoms. The operative mortality was high.

Coller and Winfield analyzed 30 cases of pancreatic cancer treated by cholecystgastrostomy or cholecystenterostomy (1934).

The results may be summarized in tabular form:

Oppenheimer, Glass and Netter analyzed 30 cases of pancreatic cancer similarly treated with the following end-results:

19 survivors—2 lost sight of.
17 survivors—14 died in first year. Average length of life, 7 months.
10 survivors were benefited definitely. Three questionably so. Four no benefit.

Palliative surgical procedures are therefore of definite value for a limited time. Any additional method which may give prolonged palliation and life expectancy is accordingly more than justifiable.

EXPERIMENTAL IRRADIATION OF NORMAL PANCREAS

Very little experimental work relative to irradiation of the pancreas or tumors arising in this organ has been published. Yet these few experiments have been of significant value.

In 1926 Fisher, Groot and Bachem studied the effect of exposure of the isolated pancreas of the dog to measured doses of roentgen rays. The tail, or one-third of the entire gland, was brought to the surface of the abdomen for irradiation. The blood supply to the gland was not molested. The factors of roentgen treatment were 140 kv., 5 ma., 4 mm. Al, 8-inch target-skin distance; 3, 4 and 5 erythema doses were applied to the surface of the tail of the pancreas.

TABLE I (Coller and Winfield)

Symptoms	No.	Died in Hospital	Complete Relief	Partial Relief	None	No Report
Jaundice	27	8	9	9	1	—
Pruritus	17	6	11	—	—	—
Pain	15	1	7	5	1	1
Nausea	12	2	11	1	2	1
Vomiting	12	2	8	1	2	1

Operative mortality 25.6%.

The survivors lived 7.2 months; 78.25 per cent of survivors were relieved of pain; 94.74 per cent of survivors were either partially or completely relieved of jaundice.

Dog I. Given 3 skin erythema doses (S.E.D.). Glycosuria on the thirteenth day for ten days. The irradiated portion of the gland was fibrous and degenerative. Regenerated lobules of normal gland appeared around the periphery.

Dog II. Given 4 S.E.D. Never developed diabetes. Killed on the 157th day. The portion of the pancreas treated with roentgen rays had disappeared entirely. At the base of the duct was sufficient regenerated pancreas to account for the non-development of diabetes.

Dog III. Given 4 S.E.D. Polyuria and complete diabetes developed in six weeks; then gradual reduction of glycosuria yet the dog died. The irradiated portion of pancreas disappeared entirely, but regenerated tissue appeared near the base of the ducts.

Dog IV. Given 5 S.E.D. Glycosuria occurred at once. Diabetes developed in eight days, and death occurred in sixty-eight days. Not a trace of pancreas was found at autopsy.

One must conclude from the above experiments that:

1. Normal pancreas of the dog can be completely destroyed by roentgen irradiation, employing certain factors, and delivering as little as 3 S.E.D.

2. The major portion of the parenchyma of the normal pancreas of the dog can be destroyed by 4 S.E.D. without the development of diabetes.

3. The normal pancreas of the dog regenerates very rapidly.

Leven, in 1933, published the results of interstitial irradiation of the canine pancreas. Gold radon seeds were inserted into the head of the pancreas and after recovery from the operation the dogs were sacrificed in several weeks. Fibrosis and atrophy, mainly of the acinar elements, were observed. In 4 dogs small areas of necrosis were seen, but in no cases was there damage to the adjacent duodenum. He is of the opinion that radon implantation is a safe procedure for suitable pancreatic cancers and prefers this method to external irradiation because of its supposed accuracy.

This limited material suggests that the normal pancreas of the dog is sensitive to irradiation, in fact can be completely destroyed. What is the effect of such procedure on pancreatic cancer in the human?

RADIATION TREATMENT OF PANCREATIC CANCER

In 1922 Richards published 3 case reports of pancreatic cancer treated by external irradiation. The roentgen treatment was directed through three portals, each treated once on successive days, employing 10 mm. of aluminum and 1 cm. of sole leather as filter, delivering an erythema dose to each field. This procedure was repeated twice at monthly intervals. One patient gained 29 pounds; roentgenograms which previously showed a displacement of the duodenum, demonstrated normal shadows and the patient was alive and well at the time of the report (ten months). A second patient treated similarly gained 20 pounds, was living and well at the time of the report (twenty months) and had no palpable evidence of disease. The third patient died of severe hemorrhage five weeks after the inception of treatment.

Other investigators have described unusually surprising results. Of these Flicker and Cameron, and Orndoff, Farrell and Ivy have been the most enthusiastic. Miramond de Laroquette recorded the first published case treated by roentgen rays in the French literature; diathermy was used to supplement the roentgen irradiation with the result that the patient was living at the time of his report, eight months after the completion of treatment without demonstrable evidence of cancer. Merritt and Rathbone reported the case of a patient who was symptom-free for a year and subsequently died of recurrence and metastases. Hayer's patient lived eight months, improving so much that laparotomy was performed to give further palliation, but unfortunately death occurred from hemorrhage.

On the other hand, of Leven's 4 patients, 2 died before the effect of the roentgen irradiation was complete, and the other 2 patients lived two and five months respectively.

Handley treated the largest number of pancreatic cancers by interstitial irradiation. Of 7 patients so treated, 4 died postoperatively. Of the remaining 3, one lived

TABLE II

TWENTY-THREE PATIENTS WITH PANCREATIC CANCER WERE TREATED BY RADIOTHERAPEUTIC METHODS (EXTERNAL, INTERSTITIAL OR BOTH)

Case No.	Name	Diagnosis Established by	Treatment		High Voltage Roentgen Therapy		Radium Element Pack		Result
			Begun	Ended	Intermittent	Fractionated	Intermittent	Fractionated	
I	E.B.	Clinical diagnosis mass in abdomen; jaundice; gastrointestinal series	2/11/28	3/25/28	—	—	—	Yes	10½ months. Weight gain. Feels better
II	T.K.	Laparotomy—biopsy	11/26/27	11/17/27	—	—	Yes	—	Unreported
III	A.S.	Laparotomy—biopsy	9/17/26	9/27/26	—	Yes	—	—	2 months. No effect
IV	W.C.	Laparotomy	8/25/26	8/28/26	Yes	—	—	—	2 weeks. No effect
V	J.R.	Laparotomy	1/29/25	2/ 7/25	—	—	Yes	—	Improved
VI	I.P.	Laparotomy	9/15/25	10/10/25	—	Yes	—	—	5 months. Tumor smaller
VII	N.E.	Laparotomy	4/23/23	12/19/23	Yes	—	—	—	10 months. Poor result
VIII	T.K.	Laparotomy	5/21/21	2/13/23	Yes	—	—	—	2 years. Slightly improved
IX	S.W.	Laparotomy—biopsy	9/29/26	9/15/26	Yes	—	Gold seeds 32 mc.	—	3 months. Slightly improved
X	C.C.	Laparotomy—biopsy	6/29/32	7/19/32	—	700 kv.	—	—	17 months. Good digestion
XI	J.L.	Laparotomy—biopsy	2/ 2/32 9/ 1/32	2/21/32 10/15/32	—	—	—	Yes	28 months. Excellent for 3 months; fair later on
XII	J.R.	Laparotomy—biopsy	10/19/32	11/13/32	—	—	—	Yes	One month. Poor
XIII	L.S.	Laparotomy—biopsy	3/ 2/33 12/ 4/32	3/20/33 12/23/32	—	—	Gold seeds 38.5 mc.	Yes	16 months. Tumor smaller. Gain in weight
XIV	H.B.	Laparotomy—biopsy	4/28/33	5/22/33	—	Yes, at 150 cm.	—	—	3½ months. Poor
XV	F.B.	Laparotomy—biopsy	—	—	—	—	Gold seeds 50 mc.	—	6 months. No effect
XVI	M.P.	Laparotomy—biopsy	9/20/34	9/28/34	—	—	—	Yes	1 month. No effect
XVII	E.G.	Laparotomy—biopsy	3/15/35	4/13/35	—	—	—	Yes	9 months. Temporary improvement. Choledochogastrostomy
XVIII	W.K.	Laparotomy	10/ 3/35	10/16/35	—	—	—	Yes	6 months. Metastases present. No effect
XIX	G.H.	Laparotomy—biopsy	2/18/36	3/21/36	—	Yes	—	—	3 months. Tumor regressed almost completely but recurred
XX	A.C.	Laparotomy	7/16/37	8/21/37	—	—	—	—	1 month. Widespread metastases. No palliation
XXI	G.M.	Laparotomy	5/27/37	6/26/37	—	—	—	Yes	1 month
XXII	H.B.	Gastrointestinal series, biopsy neck node	6/23/37	7/12/37	—	Yes	—	—	3 months. Almost complete regression of mass. Living
XXIII	J.B.	Cholecystjejunostomy	4/13/34	5/10/34	—	—	—	Yes	3 years. No palpable disease for 2½ years

for fourteen years. The lack of a positive biopsy specimen partly invalidates such a report. The second patient with a proved microscopical diagnosis lived for two years. At a second operation all signs of cancer were gone, but subsequent necropsy revealed recurrent tumor. The third patient was living for ten months without evidence of recurrence at the time of the report. The dose employed in all cases was 700–1,000 mg-hr.

Technique of Roentgen Therapy of Pancreatic Cancer. The roentgen factors employed are as follows: 200 kv. (peak); 30 ma.; 70 cm. target-skin distance; 0.5 mm. copper filter; 250–300 r daily alternating to the two or more fields until each portal receives from 2,400 to 3,600 r.

In the presence of a palpable mass, treatment is directed to a portal outlined over the abdomen anteriorly and to the dorsolumbar region opposite to it. Otherwise the patient is roentgenoscoped after barium swallowing and a portal is outlined over the site of the displaced duodenum, i.e., in the region encompassed by the duodenal loop. When the patient has undergone exploratory laparotomy some form of mark is left on the skin of the anterior abdominal wall to identify the site of the underlying tu-

mor. A total dose of about 2,400 r is delivered to each portal over a period of about eighteen to twenty days. At that time the local and constitutional response to treatment is reconsidered and additional dosage may be cautiously given, depending on the condition of the skin and the general status of the patient. With the patient under close observation, a total dose of 3,000–3,600 r may be attained. A transfusion of 500–700 cc. of whole blood is usually given during the course of treatment or immediately afterwards. The patient is likewise supported by daily intramuscular injections of liver extract. Nembutal gr. 3/4 is frequently administered one-half hour before treatment in order to allay nausea and nervousness.

Technique of External Irradiation by Radium Element Pack. Two fields for irradiation are outlined on the anterior and posterior abdomen, as described previously, when roentgen rays are employed as a source of external irradiation.

The radium in a 4-gram element pack is applied at a radium-skin distance of 15 cm. with a filter the equivalent of 1 mm. of platinum. Eight thousand milligram-hours (8 gram-hours) are given daily to one field, alternating the portals until a total of 80,000 mg-hr. has been delivered to each field. The dosage is then reconsidered and additional therapy may be given cautiously until a total of 100–120,000 mg-hr. has been attained.

Supportive measures are routinely administered as described previously under the section on roentgen therapy.

Technique of Interstitial Irradiation of Pancreatic Cancer. Gold-filtered radon seeds are available at the time of exploratory laparotomy. If it is decided to utilize this source of irradiation the operator must proceed with extreme caution. Abdominal viscera cannot tolerate curative doses of interstitial irradiation. Necrosis, hemorrhage and peritonitis are the inevitable results of such therapy. We have never attempted to implant a dose of radon greater than 3 to 4 S.E.D. except in one instance. Bleeding is usually controlled without difficulty by the coagulating current.

This form of therapy must be supplemented by external irradiation either by means of high voltage roentgen rays or by the radium pack.

END-RESULTS OF TREATMENT

Twenty-three patients with cancer of the pancreas were treated by irradiation at the Memorial Hospital in the years 1922–1937. In all but one patient the diagnosis was proved by laparotomy, biopsy or both. This one patient had painless jaundice of the obstructive type, a palpable abdominal mass, and the typical displacement of the duodenum observed on roentgenograms after barium swallowing. He died ten and a half months after the completion of radiation treatment.

SUMMARY AND INTERPRETATION OF END-RESULTS

Number of patients treated by high voltage roentgen rays, usually 200 kv.:

1. Intermittent dose.....4
2. Fractionated dose.....8

Radium pack:

1. Intermittent dose.....2
2. Fractionated dose.....8

Interstitial irradiation alone.....1

23

Of these:

(*a*) Two patients received supplementary interstitial irradiation in addition to external irradiation.

(*b*) One patient was treated by 700 kv.

(*c*) Three patients were treated by 200 kv. at 100 cm.

Average duration of life from completion of irradiation until death in all cases .....8.06 months.

1. Patients treated by high voltage roentgen rays:
   (*a*) Intermittent..... 9.37 mo. (4 cases)
   (*b*) Fractionated..... 5.06 mo. (8 cases)
2. Patients treated by radium pack:
   (*a*) Intermittent..... 2.5 mo. (2 cases)
   (*b*) Fractionated..... 12.8 mo. (8 cases)
3. Patients treated by interstitial radium (alone):
   ..... 6.0 mo. (1 case)

Of these:

(*a*) Two patients treated by supplemen-

tary interstitial radium lived 3 months, 16 months.

(*b*) One patient treated by 700 kv. lived 17 months.

(*c*) Three patients treated by 200 kv. at 100 cm. lived 3.5, 3.1 month.

Eight patients had very definite palliation with improved appetite and gain in weight for an average of 17.2 months (34.7 per cent).

Six of these 8 patients experienced definite regression of the tumor, or 26 per cent.

All but one were treated by the fractionated dose principle.

Thirteen patients had positive biopsy specimens. The average duration of life of these patients after irradiation was approximately the same as for the group as a whole, namely, 7.23 months.

Of these:

Five patients, or 38.46 per cent, experienced definite palliation and regression for an average period of 13.4 months.

CASE REPORTS

Four of these patients showed such unusual palliation and longevity after radiation therapy that their case reports are appended. F. W. Stewart has reviewed the sections and is unable to demonstrate any particular radiosensitivity. The material at hand is so limited that definite statements regarding radiosensitivity of pancreatic cancer is of little value from histological study alone.

Case 1. C. C., an Italian woman, aged forty-nine, was admitted to the Memorial Hospital on February 29, 1932, complaining of a lump in the left side of her neck. This was said to have been present since 1929 but had recently enlarged. A mild indigestion had been complained of for a year, but recently, actual epigastric pain, relieved by food and aggravated at night, was becoming more prominent.

On physical examination a deep mass was palpated in the right upper abdominal quadrant, as well as a chain of hard, fixed lymph nodes in the left anterior cervical region. The trachea was displaced to the right. A small nodule in the right thyroid isthmus and induration of the left thyroid lobe were discovered.

Roentgenographic studies made at this time demonstrated the following findings: (*a*) a rounded shadow in the mediastinum; (*b*) a nonfunctioning gallbladder; (*c*) deformity of the duodenal cap typical of duodenal ulcer, and (*d*) spastic colitis.

A cervical lymph node was excised; it was studied in the laboratory by Dr. Ewing who described the section as showing metastatic adenocarcinoma; primary site undetermined.

The blood count showed a secondary anemia, with normal white blood count. The Wassermann test was negative.

Radiation treatment was given to a cervical lymph node containing metastatic cancer by means of a radon tray at 3 cm. distance for a dose of 2,500 mc-hr.

Between March 18 and July 19, 1932, the patient was treated by means of the 700 kv. roentgen machine, employing the following factors: filter, 5 mm. Cu; target-skin distance, 65 cm.; circular 8 cm. portal; 250 roentgens daily being delivered to each field. The following fields were treated and given the total dose ascribed to each: left neck, 2,940 r in 7 treatments; right neck, 3,066 r in 7 treatments; right upper epigastrium, anterior—3,292 r in 14 treatments, posterior—2,250 r in 9 treatments; right supraclavicular space, 2,000 r in 8 treatments; left supraclavicular space, 2,000 r in 8 treatments.

From June 21 to 24, 1933, the mediastinum was treated through two fields, one anterior and one posterior, alternating portals daily, by means of 200 kv., at 70 cm. target-skin distance; 600 r was given daily.

The diagnosis at first was carcinoma of the gallbladder with widespread metastases. One month after completion of the radiation treatment in August, 1933, the patient was gaining weight and had no complaints. The abdominal mass was one-half its previous size. During the next few months vomiting occurred and after a gastrointestinal roentgen series this was found to be caused by pyloric obstruction. On December 5, 1932, a gastroenterostomy was performed. At the laparotomy a cancer of the pancreas, posterior to the first part of the duodenum was revealed. Numerous small metastatic nodules were seen in the liver at the same time. In spite of these findings, the patient continued to gain weight and improve after gastroenterostomy. In December, 1933, the liver became very large and nodular. Metastatic deposits recurred in the neck. She failed all

other appointments and probably died soon after of recurrent cancer.

Result. Seventeen months of palliated life from time of irradiation to death.

Case II. L. J., male, Jewish, aged fifty-six, was admitted to the Memorial Hospital on January 25, 1932. His chief complaint was epigastric distress of six months' duration. In the next few months nausea and jaundice occurred. A gastrointestinal roentgen series showed a filling defect on the lesser curvature of the pylorus. Laparotomy was performed on September 5, 1932, revealing the presence of a hard mass in the head of the pancreas. A cholecystgastrostomy was constructed and within ten days the jaundice disappeared. Diabetes soon intervened requiring 30 units of insulin twice daily. A weight loss of 25 pounds occurred.

Roentgenographic studies of the stomach and duodenum revealed a distortion of the duodenal cap. The duodenal loop was displaced medially and backward behind the stomach.

The stool was negative for starch and blood. The blood count was within normal limits except for a slight leukocytosis of 11,700 white blood cells, with a normal differential distribution. The blood sugar estimation was 190 mg. but diminished under roentgen therapy of the pancreas to 159 mg.

Pathological examination of a biopsy specimen aspirated from a supraclavicular lymph node revealed metastatic adenocarcinoma.

Radiation treatment was given by means of the 4-gram radium element pack between February 2 and 21, 1932, directed at the abdomen anteriorly and posteriorly. 8,000 mg-hr., employing filtration of 2 mm. lead and a radium skin distance of 15 cm., were given daily, alternating portals until a total of 80,000 mg-hr. was delivered to each field. This same course of treatment was repeated, starting on September 1, 1932, and ending on October 15, 1932.

The initial response was splendid. Gain in weight was noted and the insulin dosage was greatly decreased. Later no insulin was needed. In August, 1932, the symptoms recurred and he was treated again by the radium element pack. He immediately gained weight and maintained a good digestion. Jaundice never completely disappeared until a year and a half later. In January, 1934, a supraclavicular lymph node became enlarged. An aspiration biopsy was performed and a diagnosis of metastatic cancer was established. From this time on he progressively became worse and died on June 16, 1934.

Result. Twenty-eight months' duration of life from the time of radiation therapy to death. The most remarkable result was the disappearance of all evidence of diabetes following external radiation therapy of the pancreatic cancer. When the tumor recurred with jaundice supervening, the diabetes also reappeared.

Case III. S. L., an emaciated woman, aged sixty-four, was admitted to the Memorial Hospital on November 18, 1932. Her history was as follows: In 1918 she was treated for gastric ulcer with apparently complete relief. About August, 1931, she first noticed a lump in the mid abdomen which grew slowly until it attained the size of a grapefruit. During this time she lost 10 pounds. On September 22, 1932, a laparotomy was performed. Marsupialization of a pancreatic cyst with implantation of 50 mc. of gold radon seeds was accomplished at this time.

Upon admission she was seen to be an elderly woman, in poor general health. To the left of the umbilicus was a draining sinus, communicating with a fixed recurrent inoperable tumor, 7 cm. in diameter.

Roentgenograms of the gastrointestinal tract showed a striking deformity of the stomach due to displacement of it and the duodenal cap to the left by an extragastric mass. The antrum and duodenal cap were greatly elongated. A tentative diagnosis of cancer of the pancreas was suggested.

Microscopic study of tissue previously secured at the laparotomy revealed a papillary adenocarcinoma, Grade 2 plus. The blood count showed a mild secondary anemia and a normal white blood count. The blood sugar was reported as 90 mg. per 100 cc. of blood. The Wassermann test was negative.

Radiation treatment was given by the radium element pack employing a filter equivalent to 2 mm. of lead and a radium-skin distance of 15 cm. The abdomen was treated through anterior and posterior fields each alternating daily, receiving 8,000 mg-hr. at a treatment. Each portal received a total dose of 80,000 mg-hr. The treatment period was sixteen days. This same treatment was repeated three months later.

The patient gained weight and the tumor

decreased in size. On August 28, 1933, 38.6 mc. of radon in gold seeds was inserted into persistent tumor. Death occurred on May 15, 1934.

Result. Sixteen months of palliation from onset of radiation therapy to death.

CASE IV. J. B., female, aged sixty-four, was admitted to the Out Patient Department of the Memorial Hospital on April 13, 1934, complaining of jaundice and itching which began in September, 1933. It was accompanied by no other symptoms. Cholecystduodenostomy was performed at the Lahey Clinic, relieving the jaundice completely. She then gained 20 pounds in weight.

Her family history was interesting in that her father died of lingual cancer and a brother died of duodenal cancer at the age of twenty-six.

On physical examination a well-healed midline epigastric scar was seen beneath which a hard fixed tumor could be seen and palpated.

Roentgenographic studies revealed the displaced duodenal loop so frequently encountered in pancreatic cancer. The Wassermann test was negative. The stool contained no fat. The icteric index was negative after the cholecystduodenostomy. The blood count was within normal limits.

Radiation treatment was started by means of the radium element pack with the usual factors of 15 cm. radium-skin distance and filtration equivalent of 2 mm. of lead. An anterior and a posterior abdominal field were marked out, cross-firing at the tumor; one portal was treated daily with 8,000 mg-hr. until a total dose of 100,000 mg-hr. per portal had been given. This treatment was administered between April 14 and May 18, 1934.

The duodenal loop was normal after barium swallowing and the tumor was no longer palpable five months later. Her condition remained excellent until December, 1936, when she complained of postprandial distress. She died in July, 1937.

Result. No palpable tumor for two and a half years. Total duration of life from radiation therapy to death was three and one-quarter years.

A PROPOSED FORM OF TREATMENT FOR INOPERABLE PANCREATIC CANCER

In view of the experimental and clinical evidence that the pancreas is often sensitive to irradiation and that regeneration does occur, the following method of treatment is suggested.

1. Exploratory laparotomy and recovery of a biopsy specimen. Frozen sections should be made to determine the diagnosis.
2. Cholecystenterostomy or cholecystgastrostomy in the presence of jaundice.
3. Implantation of measured tissue doses of radon seeds.
4. Subsequent external irradiation, preferably by a radium element pack and repeated in an interval of three to six months. Four skin erythema doses (intratumoral) should be the dosage employed in each series of treatments.

REFERENCES

1. COLLER, F. A., and WINFIELD, J. M., JR. Evaluation of palliative operation for cancer of pancreas. *Am. J. Surg.*, 1934, *25*, 64–69.
2. EWING, J. Neoplastic Diseases. W. B. Saunders Co., Philadelphia, 1928.
3. FISHER, N. F., GROOT, J. T., and BACHEM, A. Effects of x-ray on pancreas. *Am. J. Physiol.*, 1926, *76*, 299–305.
4. GORDON-TAYLOR, G. Radical surgery of cancer of pancreas. *Ann. Surg.*, 1934, *100*, 206–214.
5. HANDLEY, W. S. Pancreatic cancer and its treatment by implanted radium. *Ann. Surg.*, 1934, *100*, 215–223.
6. HAYER. Die Strahlenbehandlung der Krebse des Magens und der in das Duodenum ausscheidenden grossen Drüsen. *Med. Klin.*, 1936, *32*, 1733–1736.
7. JUDD, E. S., and HOERNER, M. T. Surgical treatment of cancer of head of pancreas and of ampulla of Vater. *Arch. Surg.*, 1935, *31*, 937–942.
8. LEVEN, N. L. Experimental study; effect of radium emanation on pancreas of dogs. *Am. J. Cancer*, 1933, *18*, 899–904.
9. MERRITT, E. A., and RATHBONE, R. R. Diagnosis and roentgen treatment of cancer of head of pancreas. *Radiology*, 1936, *26*, 459–464.
10. MIRAMOND DE LAROQUETTE. Tumeur du pancréas et de l'estomac traitée par la radiothérapie et la diathermie. *J. de radiol. et d'électrol.*, 1927, *11*, 204–206.
11. RICHARDS, G. E. Possibilities of roentgen-ray treatment in cancer of pancreas. AM. J. ROENTGENOL. & RAD. THERAPY, 1922, *9*, 150–152.
12. STOUT, A. P. Human Cancer. Lea & Febiger, Philadelphia, 1932.
13. WEISS, SAMUEL. Diseases of Liver, Gall Bladder Ducts and Pancreas. P. B. Hoeber, Inc., New York, 1935.

Vol. 40, No. 5

CARCINOMA OF THE URINARY BLADDER, CERVIX UTERI AND PROSTATE TREATED BY SUPERVOLTAGE ROENTGEN RAYS*

SUPPLEMENTARY REPORT

By JOHN E. WIRTH, M.D.
From The Tumor Institute of the Swedish Hospital
SEATTLE, WASHINGTON

IN A PAPER[3] read before the American Roentgen Ray Society in September, 1935, there were reported, in addition to other experiences, 10 cases of advanced carcinoma of the urinary bladder treated with supervoltage roentgen therapy. Analysis of the detailed case reports showed 3 patients dead with disease and 7 patients alive and well eight to fourteen months after treatment. During the last two years 1 of these remaining 7 patients has expired. At the time of the previous report it was noted that this particular patient had residual disease. Thus of the original 10 patients, 6 are alive and apparently free of disease for from two years and nine months to three years and three months.

The same report contained 7 cases of advanced carcinoma of the cervix uteri. Three of these were cervical stump cases; 1 is alive for two and one-half years and still apparently free of disease, 1 developed a recurrence at twenty-one months but is alive with disease for two years and ten months, the third died of recurrent disease at twenty-one months. Of the 4 cases of regular carcinoma of the cervix 2 are still alive—one for three years apparently still free of disease and the other living for thirty-three months but developed a recurrence at twenty-two months. The results with these cases of carcinoma of the cervix have not been as striking or as lasting as those with the bladder cases. We still use this method and recommend it for palliation of advanced carcinoma of the cervix but wherever possible we supplement it with radium.

In the present report we wish to give briefly some of our experiences with an additional 18 cases of advanced carcinoma of the urinary bladder, 13 cases of advanced carcinoma of the prostate and a few remarks regarding the protracted doses of supervoltage roentgen rays combined with radium treatment for carcinoma of the cervix and corpus uteri.

The apparatus used is the same as that previously described.[3] The treatment factors are somewhat altered as regards number of portals and the filter. All of the following cases were treated with 800 kv. (peak) (rotary voltmeter[1]) and 10 ma., with a filter of 3 mm. of brass plus 1 cm. of water (inherent filter) plus 3.7 mm. of lead in addition to a secondary filter of an ionization chamber containing 2 mm. of aluminum, and 1 mm. aluminum and 3 mm. of celluloid in the diaphragm support. The patient is placed 10 cm. from the limiting diaphragm; a target skin distance of 70 cm. is used and the treatment is given at an intensity of 60 "equivalent" r per minute.

For the sake of clarity and brevity, the 18 cases of cancer of the bladder are summarized in tabular form. Inasmuch as this is a report of experiences with supervoltage roentgen therapy the major portion of the space is given to treatment factors, dosage and reaction rather than to other details of symptoms, physical signs, size of tumor, classifications, etc. Seventeen were advanced infiltrating carcinomas while one was an extensive papillary carcinoma involving almost the entire bladder wall but which apparently had not perforated through the musculature.

DISCUSSION OF CASES OF CARCINOMA OF BLADDER

Sex and Age. No particular features are noted under this heading that may be

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

TABLE I*

SUMMARY OF EIGHTEEN CASES OF CARCINOMA OF THE URINARY BLADDER TREATED BY SUPERVOLTAGE ROENTGEN RAYS

N.E.D. No evidence of disease
C.A.P. Center anterior pelvis
L.P.P. Left posterior pelvis
R.P.P. Right posterior pelvis
Rx. Radiation treatment
Perin. Perineal portal—always with 200 kv. (peak) roentgen rays
r Measured in air without back-scatter (equiv.)
12 12 cm. circular skin portal
14×10 14×10 cm. rectangular skin portal

Patients				Duration of Symptoms		Previous Treatment	Pathologist's Report	Roentgen Treatment Factors					Reactions Local and General	Complications	Survival to Death		Survival Living		Remarks
								Days Treated	Portals		Dosage in r								
No.	Name	Sex	Age	Yr.	Mo.				No.	Size					Yr.	Mo.	Yr.	Mo.	
I	GA	M	62	1		Left nephrectomy. Right ureteral transplantation	Infiltrating squamous carcinoma	44	4	12 14×10 9	C.A.P. L.P.P. R.P.P. Perin.	350×15=5250 250×16=4000 250×16=4000 300× 6=1800	Slight wet desquamation. Mild proctotitis and diarrhea	None			1	3	Well and working N.E.D.
II	BB	F	62		2	Partial transurethral resection	Papillary carcinoma Grade IV	21 42 12 33	3	12 14×10 R.P.P. C.A.P. 14×10 L.P.P. R.P.P.	350× 8=2800 250×10=2500 250×10=2500 350×10=3500 250×10=2500 350×10=2500		Very little reaction on skin. Severe dysuria, diarrhea, vomiting. Rx. stopped for 7 weeks before resumption	Extension of disease through bladder to uterus		6			Extensive abdominal disease with obstruction of ureters
III	JB	M	63		6	Partial transurethral resection	Papillary carcinoma Grade IV	39	3	12 14×10 12	C.A.P. L.P.P. R.P.P. C.P.P.	350×14=4900 250×14=3500 250×14=3500 350× 2= 700	C.A.P. Slight wet desquamation. Mild diarrhea	Gradual extension of disease to abdomen and metastasis to left femur		5			
IV	EC	M	64	1		Partial transurethral resection	Papillary carcinoma Grade II	30	4	12 14×10 9	C.A.P. L.P.P. R.P.P. Perin.	350×11=3850 250×11=2750 250×11=2750 375× 2= 750	Moderate erythema. Severe diarrhea, nausea and vomiting	Had to stop Rx. because of inanition		10			
V	GH	M	46		6	None	Infiltrating carcinoma	36 35 28	4	12 14×10 	C.A.P. R.P.P. L.P.P. R.L.P.	350× 9=3000 350×12=4500 350× 4=1400 350× 4=1400	Mild erythema; mild nausea	Developed metastasis to right ischium before completion of Rx.		5			
VI	SH	M	64		6	Partial transurethral resection	Papillary carcinoma Grade IV	35	5	12 14×10 12 9	C.A.P. L.P.P. R.P.P. C.P.P. Perin.	350×14=4800 300×12=3900 300×12=3900 350× 6=2000 300× 8=2400	C.A.P. wet desquamation of superficial epithelium. Others, severe erythema	None			1	5	Well and working N.E.D.
VII	CH	M	70	1	wk.	None	Solid papillary carcinoma Grade IV	36	4	12 14×10 12	C.A.P. L.P.P. R.P.P. C.P.P.	350×13=4550 250×15=3850 250×15=3850 350× 2=700	C.A.P. mild desquamation. Others mod. erythema; mild diarrhea	Associated with diverticulum. Intercurrent disease coronary thrombosis		8			N.E.D. in bladder at time of death
VIII	HI	M	44		1	None	Papillary epidermoid carcinoma	42	4	12 14×10 9	C.A.P. L.P.P. R.P.P. Plus 20 C.A.P. L.P.P. R.P.P. Perin.	200× 8=1750 250× 6=1500 250× 6=1500 0 kv (peak) 300× 7=2100 250× 6=1500 250× 6=1500 250× 7=1750	Only moderate wet desquamation of superficial epithelium; slight general reaction	Developed generalized furuncles 10 days after Rx. Those in irradiated areas sloughed		11			Died from complications following a slough of skin of anterior abdominal wall

										9	Perin.	250 × 7 = 1750						
IX	FM	F	56		6	Partial transurethral resection	Papillary carcinoma Grade IV	46	3	12 14 × 10	C.A.P. L.P.P. L.P.P.	350 × 15 = 5250 250 × 16 = 3500 250 × 16 = 3500	Moderate tanning; no general reaction	Extreme obesity		6			Gradual extension of disease
X	KM	F	77		3	None	Papillary carcinoma Grade IV	45	4	12 14 × 10 12	C.A.P. L.P.P. R.P.P. C.P.P.	350 × 15 = 5300 250 × 8 = 2000 250 × 8 = 2000 350 × 6 = 2100	Moderate erythema. Mild diarrhea, nausea and vomiting	Hypertension 250/16c. Chronic myocarditis; chronic nephritis		1			Disease controlled. Sudden onset of uremia. Lack of kidney function
XI	VP	M	63		10	Fulgurations 8 and 5 months previously	Papillary epidermoid carcinoma Grade III	39	4	12 12 14 × 10	C.A.P. C.P.P. L.P.P. R.P.P.	300 × 16 = 4750 200 × 18 = 3950 200 × 4 = 800 200 × 4 = 800	Moderate wet desquamation. Mild general reaction	None			2	1	N.E.D. and working
XII	JP	M	51	6	wk.	None	Papillary carcinoma Grade III	34	3	12 14 × 10	C.A.P. L.P.P. R.P.P.	350 × 14 = 4900 250 × 14 = 3500 250 × 14 = 3500	Severe local reaction with pustules and marked desquamation	Gradual decline		7			
XIII	LP	M	55	1	6	Partial transurethral resection	Papillary carcinoma Grade III	63	4	12 14 × 10	C.A.P. C.P.P. L.P.P. R.P.P.	250 × 23 = 5950 250 × 10 = 2250 250 × 18 = 4450 250 × 18 = 4450	C.A.P. Bright erythema R. & L.P.P. very slight vesiculation. Very sl. general reaction.	Late stricture of rectum from edema. Hard brawny skin			1	11	9 mo. after Rx. laid up for 3 mo. with late reaction in rectum
XIV	IS	F	69	1		None	Papillary carcinoma Grade II	24	3	12 14 × 10	C.A.P. R.P.P. L.P.P.	350 × 12 = 4200 350 × 4 = 1400 350 × 4 = 1400	Only mild reaction locally. Rx. stopped because of poor general condition	Poor general condition	1				
XV	ES	M	31		1	Fulguration 5 years previously; none since	Papillary carcinoma Grade II	47	4	12 14 × 10 12	C.P.A. L.P.P. R.P.P. C.P.P.	350 × 15 = 5250 250 × 15 = 3650 250 × 15 = 3650 350 × 3 = 1050	Moderate erythema. No vesiculation. No general reaction	None			1	5	N.E.D. working as a sailor on a ship
XVI	RV	F	32		6	Suprapubic cystotomy 26 mc. in gold radon seeds 1 mo. previously	Infiltrating transitional cell carcinoma Grade III	31	3	12 14 × 10	C.A.P. L.P.P. R.P.P.	350 × 14 = 4900 250 × 14 = 3500 250 × 14 = 3500	Heavy erythema and vesiculation. Mod. diarrhea, nausea and vomiting	Late radium and x-ray reaction in rectum				11	
XVII	CW	M	63		6	Suprapubic cystotomy	Papillary carcinoma Grade IV	34	4	12 14 × 10 12	C.A.P. L.P.P. R.P.P. C.P.P.	250 × 14 = 3450 250 × 10 = 2500 250 × 10 = 2500 250 × 4 = 1000	Moderate skin erythema. Slight general reaction	Draining suprapubic wound		5			Extensive sloughing of disease from prevesical space
XVIII	AW	M	70		6	Partial transurethral resection 6 mo. previously	Squamous carcinoma	46	2	12 12	C.A.P. C.P.P.	350 × 11 = 3850 350 × 11 = 3850	Moderate erythema. Draining suprapubic wound	Prostatic obstruction of urethra			2	2	

* Figures in this table have been revised to February 1, 1938, and therefore disagree somewhat with those in the text.

classed as unusual except that one male thirty-one years of age and one female thirty-two years of age are among the 18 patients (Cases XV and XVI).

Previous Treatment. In Case XV, a male aged thirty-one, it is interesting to note that there had been some type of fulguration of the bladder five years previously for a papilloma. At the time he was seen he had an extensive papillary carcinoma, Grade II, involving approximately one-third of the entire bladder wall. It involved the dome and extended downward to both the left and right sides to the floor of the bladder. By means of palpation with the cystoscope and the hand suprapubically, the mass seemed to have penetrated the entire substance of the bladder and to have infiltrated the prevesical space. Case XVI, a female, aged thirty-two, had an infiltrating transitional cell carcinoma, Grade III. Cystoscopically this seemed to be a tumor which would be suitable for implantation of gold radon seeds. Before being referred for supervoltage roentgen therapy, she had a suprapubic cystotomy performed. The tumor was found to involve the left ureteral orifice, extended downward and outward involving practically the entire musculature of the floor of the bladder, the left wall of the bladder, and was definitely not limited by the musculature. Twenty-one gold radon seeds totaling 26 millicuries were distributed throughout the tumor. It was realized that this was far too inadequate for the size and extent of the growth so as soon as the suprapubic wound was healed and she had recovered from the reaction of the radon she was referred for a thorough course of supervoltage roentgen therapy.

At least 7 of the 18 patients treated had had previous partial transurethral resection of the redundant portion of the tumor mass by means of an endotherm cutting and coagulating current. All of these patients had been under the care of one particular urologist[2] who uses this as a routine regardless of whether or not they are to be treated subsequently by supervoltage roentgen therapy. How much influence this procedure will have upon the results is impossible to state at this time. It may be noted that of these 7 patients 3 are living and 4 are dead, while of the other 11 patients 5 are living and 6 are dead. Case I is unusual in that he had had a left nephrectomy for a hydronephrosis and pyelonephrosis as well as a transplantation of the right ureter into the rectum previous to the roentgen treatment of the bladder tumor.

Treatment Factors, Treatment and Resulting Immediate Reactions. The total treatment time in days varied from twenty-five, for those in whom treatment was not complete, to sixty-three; the average time being between thirty-five and forty-five days. It is believed that a patient cannot tolerate sufficient dosage to obliterate cancer of the bladder in less than thirty days. The majority of living patients had treatment extending over periods of thirty-five to sixty-three days.

The major portal of entry of the roentgen-ray beam is considered the center anterior pelvis. This is invariably given over the suprapubic region as a 12 cm. circular skin portal. The next most frequently used portal is a 14×10 cm. skin portal on both sides of the posterior pelvis directed slightly medially toward the bladder. The above three portals are frequently supplemented by a center posterior pelvic portal and occasionally by a perineal portal 9 cm. in diameter to which we have to apply 200 kv. (peak) inasmuch as it is impractical to reach this area with the 800 kv. tube. Only 4 cases received this supplementary poralt through the perineum with 200 kv. (peak), and 3 of these 4 are among the 8 surviving patients. They received between 1,800 to 2,400 r, given between twelve and twenty days; representing an added 3 to 5 erythemas on the skin and perhaps a third of this amount to the tumor. It is therefore an appreciable amount of radiation.

The plan of treatment throughout has been a single center anterior pelvic portal, giving 350 r on one day and alternating this with two posterior pelvic portals of 250 r each on the other day. We attempt to give at least fourteen treatments to each of

these regions so that the patient receives 4,900 r to the center anterior pelvic portal, while at the same time he receives 3,500 r to each of the two posterior pelvic portals. If his general condition warrants it, if the skin reaction is not too severe, and if we feel he is able to tolerate more treatment, additional treatments are given to either the center anterior pelvis to carry this to a higher point or a perineal portal is added or, occasionally, the center posterior pelvis is treated. In many obese patients the center anterior pelvic portal cannot be carried to 4,900 r and hence an attempt is made to make up this difference by the addition of lateral pelvic portals and a perineal portal.

Review of the local skin reactions shows that we have had real difficulty with only 1 of the 18 patients and slight difficulty with another. In the remaining 16 cases the skin reaction has varied from a moderate erythema to a heavy erythema with vesiculation and occasional desquamation of the superficial epithelium. All of these, however, have healed rapidly and left only slight late changes. One exception to this is Case XIII which had the largest amount of radiation of any of the cases. The skin of the anterior pelvis, which received 5,950 r in a period of fifty days, still shows slight thickening, fibrosis and induration while the skin of the posterior pelvic portal immediately over the sacrum is extremely brawny, fibrotic, somewhat avascular and tightly adherent with the underlying subcutaneous tissues to the pelvic bone almost two years after irradiation. Case VIII was treated by a combination of 200 kv. (peak) and 800 kv. (peak). He received only a moderate reaction consisting of a deep erythema and slight desquamation of the superficial epithelium and the skin was practically healed when he developed many furuncles over his entire body. Two of these were in the irradiated area on his suprapubic region while there was at least one in each of the two posterior pelvic regions. All of the other furuncles healed in due time but the two on the posterior pelvis were extremely slow, were associated with a great deal of reaction and necrosis over an area almost 2 cm. in diameter. They were completely healed in six weeks. The furuncle in the suprapubic region spread rapidly, was associated with necrosis of an ischemic type and extended peripherally until it had excavated an area 7 cm. in diameter and extended downward to the superficial fascia. This caused excruciating pain and the patient was critically ill for a period of three months. The entire area had not become demarcated and healed until about four months after his treatments had been completed. Case VI was somewhat similar in that he also developed numerous small furuncles which in the irradiated areas were extremely slow to heal, and undoubtedly this played a large part in his gradual decline to the point where he expired with residual disease seven months after treatment. Practically all patients having 3,500 r or more to a single portal within four weeks showed some slight superficial desquamation of epithelium. Those receiving 5,200 r had desquamation of the superficial epithelium over almost the entire area of the portal but in practically all instances this was entirely healed within seven to ten days. Case XIII had 5,950 r in approximately fifty days and showed only a bright erythema without desquamation and only a few small areas of vesiculation.

We may summarize the generalized reactions by saying that the above doses represent severe treatment. At least 60 per cent of our patients are in poor general condition when treatments are started. Six of the 18 patients were already hospitalized because of their general condition; 3 of these were able to get up before completion of their treatment and come back and forth to the hospital for their treatments. Five of the 18 patients who were not hospitalized were kept in bed at home from three to fifteen days after completion of the treatments. The remainder, however, stayed up throughout their entire course of treatment, and made the trips back and forth daily to the hospital. Practically all 18 patients suffered a mild diarrhea and 5 a severe diarrhea with an associated tenesmus and abdominal cramps. All have

shown a weight loss varying from 3 to 15 pounds. Cases I, VII, XI, XIII and XV were able to resume their normal occupation within ten days to two weeks after completion of their treatments. The same 5 patients were working or capable of working for at least two-thirds of the time of their treatment.

Of the 8 patients living from ten to twenty-six months only one (Case XIII) has developed any late complications from the treatment. This patient had been perfectly well for a period of nine months and was back at his work as a street car conductor when he developed pain in the lower pelvis, constipation alternating with diarrhea, and had to remain at home because of poor general condition. He developed a late partial stenosis of his rectum due to an indurated edema. He developed areas of ulceration in the mucosa of the lower rectum which caused a great deal of thick mucus and a small amount of bleeding. Subsequent to this he had to remain in bed almost three months before the edema and ulceration of the rectal mucosa healed. The condition gradually subsided, the stenosis of the rectum partly regressed, he again gained weight and strength and is now back at work. Other complications noted following treatment were due to an increase in general systemic diseases such as hypertension, chronic myocarditis, nephritis, or to metastasis.

Ten of the 18 patients have died. One of these died of intercurrent disease, a coronary thrombosis, eight months after completion of treatment and was entirely free of malignant disease at the time of death. The others died at intervals varying from one to twelve months after treatment, but the majority of deaths occurred between one and six months. Eight patients are now living between ten and twenty-six months. It is apparent from this that the ones who are going to show improvement will do so immediately and remain well, while those with extensive disease in whom the disease has not been controlled will rapidly succumb within a relatively short time. This same fact was noted in the original 10 cases which were reported two years ago. This form of treatment apparently has no place in the palliation of carcinoma of the bladder. It is more likely to cause a rapid decline of the patient's general health. The patient has to be in fair general condition in order to stand this extensive treatment. This is well illustrated by Case X, a white female aged seventy-seven, suffering from hypertension, chronic myocarditis and chronic nephritis. The patient stood her treatments fairly well throughout the entire course with only very mild diarrhea, slight nausea and vomiting. Ordinarily, the patients are better within a week to ten days after completion of treatment but this one, although she seemed to be perfectly well and was apparently free of disease, almost a month after treatment, developed a sudden cessation of kidney function (not ureteral obstruction) and died within four days.

Four additional cases of advanced carcinoma of the bladder which had been outlined for treatment have been excluded from this series as each received five or less treatments. The treatments in 2 of these cases were stopped because of their critical condition.

CARCINOMA OF THE PROSTATE

Thirteen cases of carcinoma of the prostate were treated with supervoltage roentgen therapy with a plan very similar to that used in the previous bladder cases. The results in the cases of carcinoma of the bladder had been so encouraging that it was hoped that the cases of carcinoma of the prostate would likewise show some definite improvement. The case reports are not given in detail nor in chart form. It is sufficient to say that all were definite adenocarcinoma of the prostate, rather advanced; 3 of the 12 cases had pelvic bony metastases. All 13 cases showed obstructive symptoms and 10 of the 13 cases had extensive bleeding growths in the bladder. Of the 13 treated cases 9 have died and 4 are living between twelve and thirty months following treatment. Two of these still have very definite active disease with gradually

extending metastases, while 2 are relatively symptom-free and show considerable regression in the size of the prostate; they have also not developed any subsequent trouble with extension into the bladder. On the whole, these patients did much more poorly than did the bladder cases and although the date of death in months varies from one to twenty months after the treatment, it was felt that the amount of palliation received did not justify the discomfort and morbidity associated with the treatments. We realize that this is an extremely small series upon which to base conclusions and that although the final answer is not here inasmuch as 4 are still living, we still feel that palliation with the older form of treatment of a few large doses to decrease pain is much more helpful than the present protracted form of extensive irradiation.

CARCINOMA OF CERVIX UTERI

During the last two years some 50 cases of carcinoma of the cervix uteri and 10 cases of carcinoma of the corpus uteri have been treated with supervoltage roentgen therapy as an adjunct to the routine radium therapy. These patients received 250 r to each of two opposing pelvic portals on one day, alternating with the opposite side on the other day with the same factors. This was given over a period of twenty-eight days so that a patient received a total of 3,500 r to each of four pelvic portals with a skin portal 14 by 10 cm. and a target skin distance of 70 cm. This represents $3\frac{1}{2}$ threshold erythemas to each of the skin portals. The radium in these cases has varied from a single dose of 3,000 mg-hr. within the cervical canal (plus 750 mg-hr. at 1 cm. distance in each of the two lateral vaults) to a divided dose technique giving 750 mg-hr. once every four to seven days for a total of 3,500 to 4,500 mg-hr. (within the cervical canal) spread over the same period of time as the roentgen therapy. In 30 to 40 per cent of the cases so treated the skin reaction was merely a mild erythema. At the other extreme there were approximately 15 per cent in which there was rather severe erythema amounting in 5 per cent to vesiculation and desquamation of the superficial epithelium, especially in the groins, and in obese individuals in the fat folds of the anterior abdominal wall. All of these reactions have healed well, leaving practically no changes, and in 80 per cent of those treated one would hardly be able to tell three months later that the patient had had roentgen treatment. We have noticed that when this form of treatment is given in conjunction with and during the same time as the protracted radium treatment, the patients have a severe generalized reaction which is much more marked than with radium alone, or when radium is used either at the beginning or at the end of the roentgen irradiation. It is in this small group that we have had the more marked systemic reactions in the form of diarrhea, dysuria, frequency, tenesmus, and edema of the entire lower pelvis, and occasionally an associated gastrointestinal disturbance resulting from edema and contracture of the bowel. In no case, however, have we seen any late reactions which could be attributed entirely to the supervoltage roentgen therapy. Any late reactions that we have seen in the form of contracture of the rectum, late edema and induration, pelvic adhesions and intestinal obstruction could be attributed to the radium, as these have happened in no higher a percentage than is customarily found with radium alone or with radium in conjunction with 200 kv. (peak) roentgen rays. We state this because we believe 3,500 r to each of four pelvic portals represents a safe routine form of treatment in conjunction with radium and that one has to be careful only in that group in which protracted radium treatment is used at the same time that the roentgen therapy is given, rather than just preceding it or immediately after it. We believe that in at least 30 per cent of the cases the dosage could be carried higher than this, whereas in only about 10 per cent of the cases does it have to be decreased. The thin, emaciated person, regardless of age, is apt to give the most trouble.

SUMMARY

Ten cases of advanced carcinoma of the urinary bladder treated with supervoltage roentgen therapy alone were reported two years ago. At that time three were dead and seven cases were alive eight to fourteen months. At the present time six of these patients are alive and apparently free of disease for from two years and nine months to three years and three months. Only one patient has died in the interval and this one had residual disease at the time of the previous report. A new series of eighteen additional cases is reported. Eight cases show apparent complete primary regression of disease from ten to twenty-six months. Ten are dead, one from intercurrent disease (coronary thrombosis eight months after treatment and showed no residual disease at the time of death) and nine with residual disease. It is interesting to note that in those who have not survived, death took place from one to seven months after completion of treatments. This same fact is notable in the first series. It is again stressed that these cases are: (1) carcinomas too advanced for resection or implantation of gold radon seeds, (2) all verified by histologic examination, (3) all cases treated by this means rather than a selection of the cases treated by supervoltage roentgen therapy alone. A summary of the case reports shows how utterly hopeless some of these cases were primarily. The treatment in this second series has been carried to a much higher total dosage than in the first. One case reported in detail shows the amount we believe to be the largest total dosage that can be tolerated, while others illustrate the average and minimum amounts given in this series. We believe a study of this form of treatment with its resultant experiences will aid others employing supervoltage roentgen rays and will help them evolve a better plan of therapy.

Results in the seven cases of cancer of the cervix uteri previously reported are not so striking. Of the three cervical stump cases one is alive for two and one-half years and is still apparently free of disease. One is alive with disease for two years and ten months. The other died of recurrent disease at twenty-one months. At the time of the previous report two of the four regular cervix cases were dead and a third developed a recurrence at twenty-two months but is still alive with disease at thirty-three months. The fourth is still free of disease at three years. No new cases are added to this series as all subsequent cases have had supplementary radium therapy.

Thirteen cases of advanced carcinoma of the prostate treated with relatively large doses of supervoltage roentgen therapy alone in a manner similar to the bladder cases are reported. Nine died between two and fourteen months after treatment. Four are living between eight and twenty-four months. The results from this meager series have led us to believe that advanced carcinoma of the prostate will not respond nearly as well as carcinoma of the bladder and leave us in doubt as to whether the amount of palliation obtained warrants the discomfort and morbidity associated with such large amounts of protracted radiation.

Protracted doses of supervoltage roentgen rays combined with radium treatment for carcinoma of the cervix and corpus uteri are discussed. It is now believed that a total of 3,500 r to each of four pelvic portals given in doses of 250 r to each of two opposing 14 by 10 cm. pelvic skin portals daily is the maximum dose that can be tolerated by the average patient with these factors. The gastrointestinal tract rather than the skin is the limiting factor.

REFERENCES

1. Henderson, J. E., Goss, W. H., and Rose, J. E. Use of rotary voltmeter for measurements up to 830 kilovolts. *Rev. Scientific Instruments*, 1935, *6*, 63–65.
2. Nelson, O. A. Carcinoma of bladder. *Urol. & Cutan. Rev.*, Feb., 1938, *42*, 95–101.
3. Ward, C. B., Wirth, J. E., and Rose, J. E. One and one-half years' experience with supervoltage roentgen rays. Am. J. Roentgenol. & Rad. Therapy, 1936, *36*, 368–380.

Vol. 40, No. 5

A NEW INSTRUMENT FOR IRRADIATION OF TUMORS OF THE NASOPHARYNX WITH RADIUM OR RADON*

By JOHN V. BLADY, M.D.
Memorial Hospital
NEW YORK CITY

TUMORS of the nasopharynx, while surgically inaccessible, are usually fairly radiosensitive, and are therefore treated preferably by radiation in the form of radium, roentgen rays or combinations of both. Irradiation of the nasopharyngeal region by roentgen rays delivered through the skin of the cheeks just lateral to the nose is fairly well tolerated, but even in heavy doses is often insufficient to produce complete regression of the nasopharyngeal growth. As has been pointed out by Martin and MacComb,[1] " . . . the beneficial effects of irradiation by any given method in a given case will increase proportionately with the dose up to a certain point. Beyond this point, the law of diminishing returns operates to an increasing degree with an increase in the total dose, so that, finally, further irradiation is not only useless but harmful. This rule applies to all technical methods of irradiation. It will be found, however, that not all of the disadvantages and harmful effects of external and interstitial irradiation are identical," (this also holds true for intracavitary irradiation) "so that the cumulative harmful effects of a combination of less than maximum doses of the two will be considerably less, and the lethal action on the tumor greater than would be the case if either method alone were pushed to its limit of safety." By such a combination of external and intracavitary irradiation in less than maximum doses of either, the desired degree of radiation effect may be produced in the nasopharynx.

The nasopharyngeal space is well suited for the intracavitary method of irradiation but, because of its anatomic structure and position, is somewhat difficult of access. In order to carry out this form of therapy successfully, therefore, several problems should be considered. The first is the lack of a suitable instrument which can be so placed as to irradiate any portion of the nasopharyngeal space. To date the greatest difficulty has been in reaching the apex of the vault of the nasopharynx which extends about 3 cm. above its floor. The second problem is the maintenance of such an instrument in its proper position during the period of irradiation. The third problem is that of minimizing as much as possible the unavoidable trauma caused by instrumentation within the nasopharynx and the presence of the apparatus in this area for a period of three to five days. Even moderate

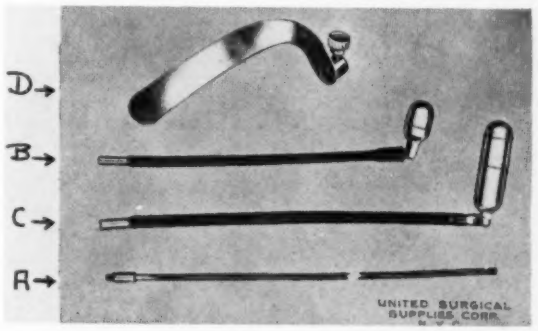


FIG. 1. The nasopharyngeal applicator guide and immobilizing attachment. *A*, the flexible guide is a 20 to 25 cm. length of a twisted steel shaft, 2 mm. in thickness. At one end a threaded sleeve is attached which serves as a fitting into the distal end of the applicator shaft. *B*, the smaller applicator is used in children. The shaft is 9 cm. in length and the capsule is 17 mm. in height. *C*, the shaft of the adult size is 11 cm. in length and the capsule can be varied from 22 to 28 mm. in height by the insertion of additional sections. In the above illustration one of the sections is *in situ*. We use three additional sections, 4, 6, and 8 mm. respectively. *D*, the top illustration shows a right immobilizing attachment, a reverse of which constitutes a left sided attachment.

* From the Head and Neck Tumor Service of the Memorial Hospital.

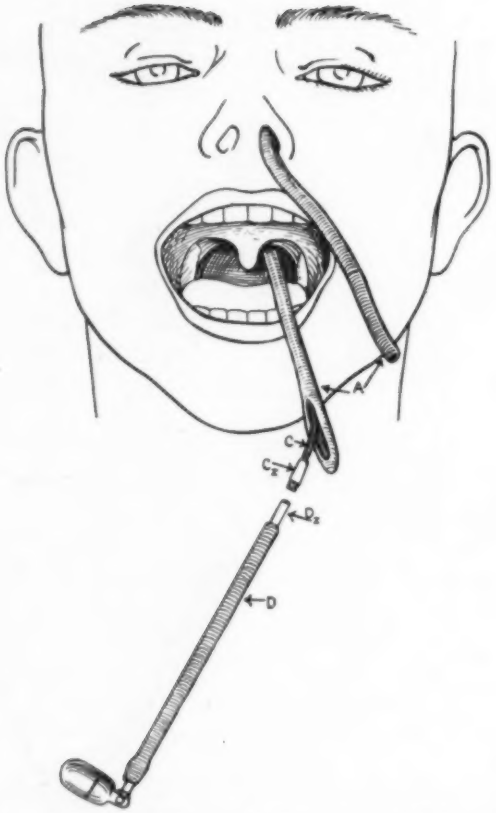


Fig. 2*a*. The rubber catheter, *A*, containing the guide, *C*, has been inserted through the left nasal cavity into the pharynx and pulled out from the mouth. The guide, *C*, is pulled out of the catheter and the applicator, *D*, is attached to it (D_z and C_z). After the applicator is securely screwed on to the guide, all metallic parts (*C*, C_z and D_z) are pushed into the catheter so as to present no irregular surfaces which might traumatize the nasal and oral mucous membranes.

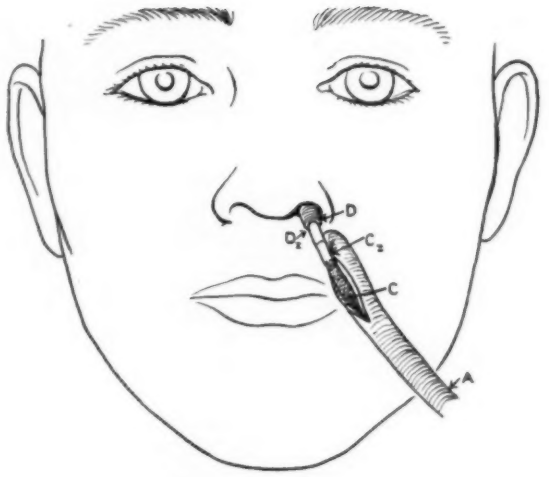


Fig. 2*b*. The catheter and guide have been drawn out of the nasal cavity, bringing the applicator into position as shown. The guide, *C*, is then detached. In this position the capsule hangs down along the dorsum of the uvula. It is readily brought into the desired position by rotating the end (D_z) clockwise. This maneuver swings the capsule through the right nasopharyngeal space into an upright position. Then, by examining the nasopharynx with a mirror, the position of the capsule is checked so as to insure its being as nearly in contact with the tumor as is possible.

trauma in the nasopharynx is not well tolerated since there may be a beginning radiation reaction due to the fractionated external irradiation just completed.

In the Head and Neck Clinic of Memorial Hospital, intracavitary radium therapy has been employed for many years in the treatment of cancer of the nasopharynx, oral cavity, larynx, antra and esophagus. During recent years nasopharyngeal tumors have been treated by a combination of irradiation with roentgen rays and intracavitary radium. One of the earliest devices used for this purpose was a special ball or capsule of monel metal containing varying amounts of radon. This apparatus was drawn into position and held in the nasopharynx by strings or cords; one string emerged from each nostril and a third from the mouth, the latter to facilitate

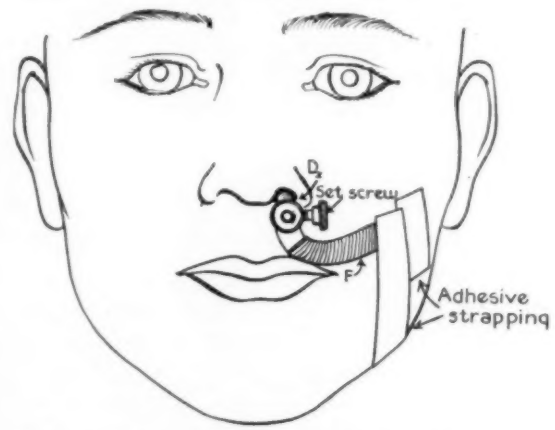


Fig. 2*c*. The immobilizing attachment has been fastened to the applicator end, D_z, by means of the set screw. Note the protective rubber that covers the metallic arm extending on to the cheek. Adhesive strapping as shown fixes and immobilizes the attachment.

withdrawal. Even though the strings were protected by threaded pieces of rubber tubing, considerable trauma was produced after several days in the nasal cavities, soft palate and lips. The string emerging from the mouth also proved to be of considerable annoyance to the patient. Any unintentional manipulation of the strings by the patient would displace the capsule, which at best was never well centered in the nasopharyngeal cavity but reposed on the upper surface of the soft palate, just behind the posterior naris.

A more recent method described by Martin and MacComb[1] is the use of a radium capsule which is enclosed in one or two layers of rubber drain and fastened securely to the middle of a No. 14 French rubber catheter. This device is then placed in position with the aid of catheters; one is inserted into each nostril and the ends are drawn out from the pharynx through the mouth.

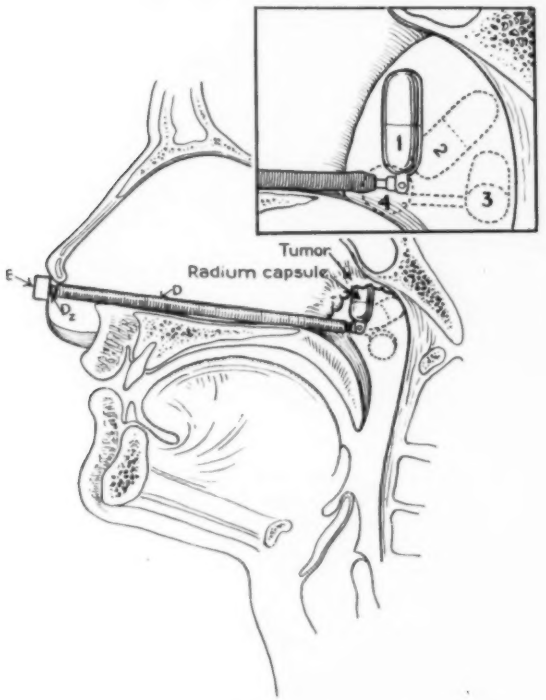


Fig. 3. Sagittal section of the nose and nasopharyngeal region demonstrating the applicator *in situ*. (Inset) An enlarged view of the capsule in the nasopharyngeal region showing all of the various positions in which it can be placed. Compare with the roentgenograms in Figures 4, 5, 6 and 7.

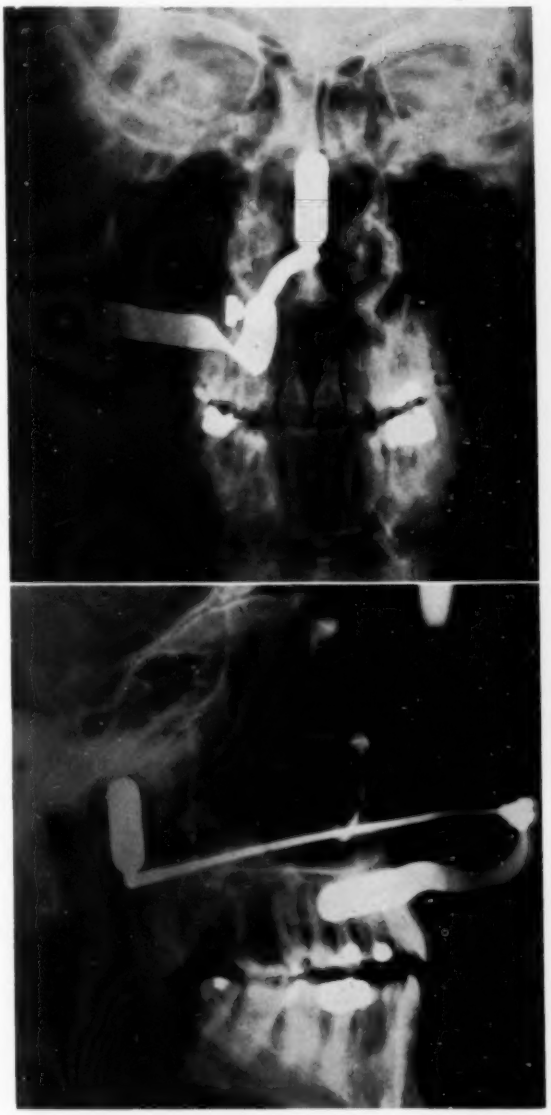


Fig. 4. Anteroposterior and lateral roentgenograms demonstrating how the apex of the nasopharynx is successfully irradiated with the capsule in this position. The radon seeds (total 15 millicuries) were concentrated in the upper third of the capsule.

The ends of the radium-bearing catheter are then fastened to the ends protruding from the mouth and are thereby drawn into the pharynx and back out through the nasal cavities. This brings the radium capsule into the nasopharynx. With this method, however, the radium can seldom be placed in close proximity to the tumor area, especially if the latter is located at the apex

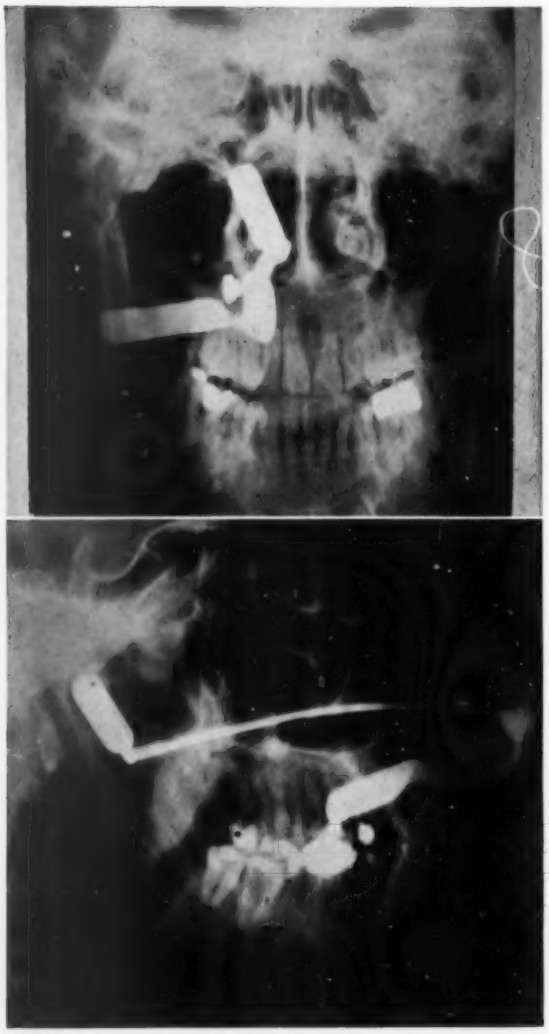


Fig. 5. Anteroposterior and lateral roentgenograms demonstrating the method of irradiating only the affected side of the nasopharynx.

of the nasopharynx. The capsule is maintained in position by fastening the ends of the catheter emerging from each nostril with adhesive. As a result both nostrils are obstructed and subjected to trauma sufficient to produce considerable discomfort. In cases where one nostril is entirely occluded by tumor, enlarged turbinates or deviated septum, the catheter method may not be employed satisfactorily.

DESCRIPTION OF APPARATUS

The present applicator (Fig. 1) consists of a capsule, which contains the radiation source, attached to a flexible steel shaft. The capsule is 8 mm. in thickness and has a bore of 4.5 mm. in width; its height can be varied from 22 to 28 mm. by the insertion of additional sections. The cavity in the capsule, into which the source of radiation is placed, is thus varied from 13 to 20 mm. The capsule is hinged so as to rotate through an arc of 180 degrees in the plane of the shaft. The latter is made of flexible steel covered by thin rubber tubing, making an overall thickness of 3.5 mm.

The cavity in the capsule is of sufficient size to permit the use of several forms of radon or radium applicators. Its minimal length of 13 mm. permits the use of needles (11 mm. length and 1.6 mm. diameter), radium or radon platinum tubes (11.5 mm.

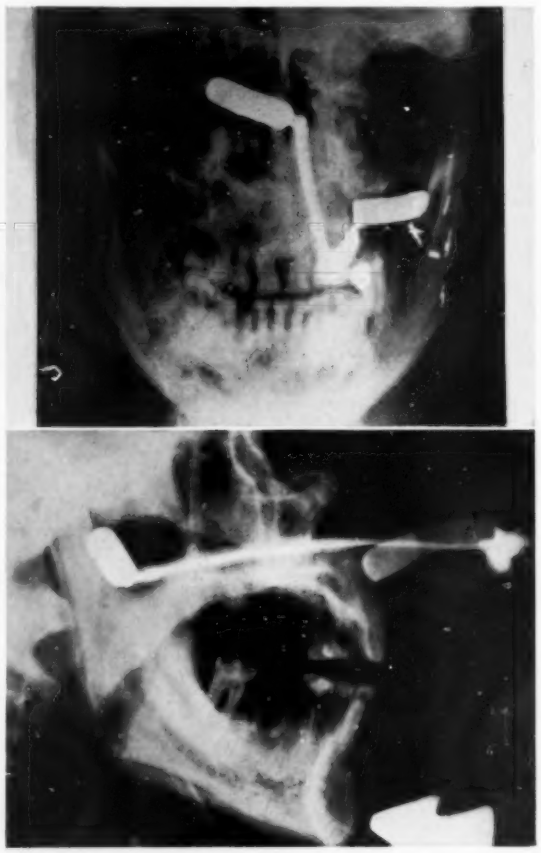


Fig. 6. Obstruction of the right nasal passage. The applicator is inserted through the left side and the capsule is placed obliquely irradiating the right nasopharyngeal wall. Patient has a metastasis in left neck treated with gold seeds.

length and 1.2 mm. diameter), or gold seeds. At the Memorial Hospital gold seeds are used because they are available at all times, easy to handle, and even though the dose of each seed is variable any required amount of radiation can be readily made up. In addition, if the intensity of the radiation source is to remain relatively constant over a period of days, additional seeds can be added from time to time. Furthermore, gold seeds can be bunched in any part of the capsule by using cotton for spacing, and this portion of the capsule is then placed in apposition to the tumor. This method of confining the radiation source is especially useful when irradiating growths located in the apex of the nasopharyngeal vault. We have been employing a total of about 15 millicuries, which left *in situ* for four days is equivalent to 1,026 mc-hr. or 7.69 millicuries-destroyed. About five to seven days later, if the mucositis is not too severe, the treatment and the dose are repeated.

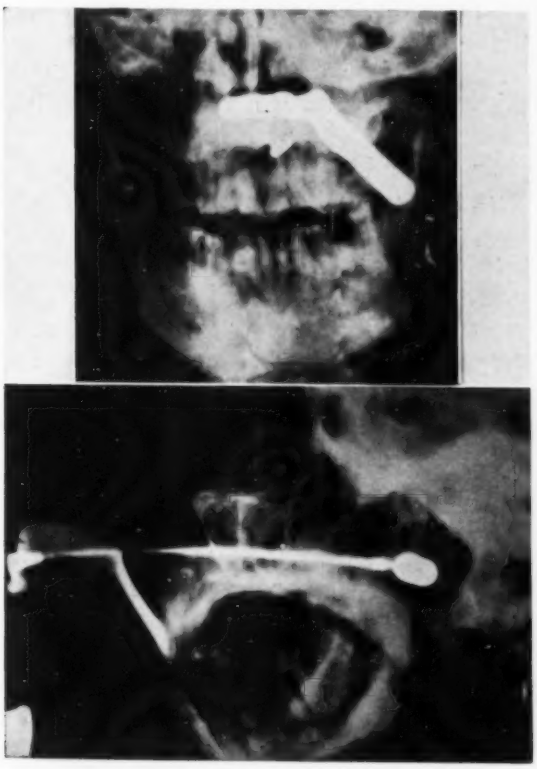


FIG. 7. Same patient as in Figure 6. The second application of radium again directed to the right side but at a slightly lower level.

FIG. 8. The nasopharyngeal applicator in place. Note cotton around the naris. The adhesive is placed around the arm of the immobilizing attachment and is fastened under the chin to prevent upward slipping. More adhesive is then applied across the arm and fastened to the upper lip and cheek as shown in Figure 9. The desquamation and blistering of the cheeks resulting from the external roentgen irradiation is clearly demonstrated.

The immobilizing attachment (Figs. 1, 2*c*, 8 and 9) consists of a strip of chrome plated copper roughly patterned in an L-shape and a small circular section which

has been soldered into the free end of the short arm. The circular section, into which the distal end of the shaft of the applicator fits, has a set screw which when applied immobilizes the shaft and maintains it in position. Right and left sided immobilizing attachments are necessary.

Fig. 9. Applicator in place. Adhesive strapping firmly fixes the immobilizing attachment. Boric ointment patch covers the area of irradiation blistering and ulceration.

The guide for the insertion of the applicator is made of a flexible steel shaft about 25 cm. in length. At one end of the shaft a threaded sleeve has been attached which fits into the distal end of the applicator shaft.

INSERTION OF APPLICATOR

The selection of the nasal cavity through which the applicator is to be inserted depends on the position of the growth in the nasopharynx and the condition of the nasal passages. If the growth is definitely on one side, the corresponding nasal cavity should be used if possible, but if the growth is centrally placed on the posterior wall the nasal passage of widest caliber will naturally be selected. For irradiation of growths in the apex of the nasopharynx the capsule is placed erect so that it impinges or buries itself in the tumor area (Figs. 3 and 4). If the nasal cavity nearest the tumor is occluded or obstructed by an enlarged turbinate or deviated septum the applicator can be inserted through the opposite nasal cavity. By placing the capsule obliquely in such a case the radiation is delivered at the tumor site (Figs. 6 and 7).

The selected nasal passage, pharyngeal and oral mucous membranes are anesthetized by a topical application and spray of a 10 per cent solution of cocaine hydrochloride. The flexible steel guide is sheathed with a No. 17 French catheter and the threaded end (C_2, Fig. 2*a*) of the guide is hidden in the aperture at the blunt end of the catheter. The latter is lubricated and inserted through the nasal cavity into the pharynx and the blunt end is pulled out from the mouth (Fig. 2*a*). The threaded end of the guide is then pulled out of the catheter and the applicator is attached to it. All metallic parts (Fig. 2*a*, C, C_2, D_2) are pushed into the catheter so that no irregular surfaces can traumatize the mucous membranes when the catheter is pulled out through the nose (Fig. 2*b*).

In this position, however, the capsule is not upright but hangs down along the dorsum of the uvula. It can be readily brought into the desired position by rotating the end of the applicator shaft protruding from the anterior naris, to the side corresponding with the nasal cavity being used. This rotation swings the capsule through the opposite side of the nasopharynx usually without difficulty so that it can be placed upright or in any desired position. Then, by examining the nasopharynx with a mirror, the position of the capsule is checked so as

to insure its being as nearly in contact with the tumor area as is possible (Fig. 3).

After the capsule has been properly placed the immobilizing attachment (Fig. 2*c*) is fixed to the end of the applicator shaft (Fig. 2*c*, D_2) protruding from the naris. Adhesive strapping is placed securely from the free end of the attachment to the submental region (Fig. 8) and additional pieces are placed over it and fastened to the cheek (Fig. 9). The attachment may be fastened very satisfactorily by placing the attachment arm along the dorsum of the nose and fixing it firmly in place with small strips of adhesive tape.

By spraying mineral oil into the nasal cavity and placing a wisp of cotton around the shaft at the anterior naris, contact trauma is prevented. As frequently as is necessary the nasal cavity should be cleared with a cotton applicator and mineral oil.

To remove the capsule the immobilizing attachment is removed and a small piece of protective rubber tubing is placed over the metallic end of the applicator protruding from the nostril. By rotating the shaft, the capsule is dislodged and now hangs down into the pharynx or rests on the free edge of the soft palate. As the shaft is pushed into the nasal passage, the capsule presents itself in the oropharynx where it can be grasped with a forceps and readily removed.

Practically any portion of the nasopharynx can be efficiently irradiated with this applicator. Figures 3, 4, 5, 6 and 7 demonstrate the various positions in which it may be placed.

Up to the present writing the applicator has been used in 25 patients for periods of from three to five days in each. Although all of these patients had received preliminary roentgen irradiation through both cheeks they have tolerated the instrument quite well and have been able to eat and sleep without undue discomfort. A mild sedative is all that is necessary to assure them of a good night's rest.

I am indebted to Mr. A. Schreiner, master mechanic of the machine shop of the Memorial Hospital, for constructing the instrument and for the many helpful suggestions in its gradual evolution, and to Dr. Hayes E. Martin for helpful suggestions and for the opportunity of its clinical application. The instrument is now being manufactured by the United Surgical Supplies Corporation, New York City.

REFERENCE

1. Martin, H. E., and MacComb, W. S. Protracted irradiation by radium. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 224–233.

PYELO-URETEROGRAPHY IN INCLINED PLANES

By R. J. PRICE, M.D.
DAYTON, OHIO

THE object of this paper is an attempt to establish the rôle of pyelo-ureterograms in inclined planes in the diagnosis of obscure urinary lesions. No originality in technique, indications or contraindications is claimed by the writer.

This examination is an adjunct to the usual intravenous and retrograde methods, and in no way replaces their use.

Since a high percentage of urinary lesions aside from neoplasms of the kidney have their origin in stasis and that being most frequent in the ureter, it would seem that careful examination of this organ would be a necessary part of the examination.

A flat film in horizontal supine position is always taken first and studied. Then the usual cystoscopic examination is done, followed by sodium iodide or sodium orthoiodohippurate injection and another film taken in Trendelenburg position. Following this the catheters are drawn down and a film taken in erect position. Films may be flat or stereoscopic; oblique or lateral films are often valuable.

These positions afford maximum excursion of kidneys and ureters and afford valuable information in determining whether a given condition is postural, functional or organic.

No small part of the success of this procedure depends on close cooperation between the urologist and the roentgenologist and a mutual understanding of their associated problems.

The lesions of the ureter, well shown by this routine, include calculus, stricture, kink, stenosis, adhesions, reduplication, mucous membrane valves, megaloureter, aberrant implantation, atresia, fascial

FIG. 1*a*. G.K., aged forty-three; admitted May 10, 1935, with pain in right upper quadrant, tenesmus, burning on urination, intermittent chills and fever. Clinical diagnosis, pyelitis. Horizontal position reveals a normal pyelogram with no apparent obstruction of the ureter.

FIG. 1*b*. Same case (G.K.). Pyelo-ureterogram in vertical posture reveals an acute angulation of the ureter opposite the third lumbar vertebra. At operation the acute angulation was found to be due to a fascial band encircling the ureter. Its removal resulted in recovery.

Fig. 2*a*. G.B., aged thirty-six; admitted November 27, 1936, complaining of intermittent attacks of pain in left side of two years' duration. Previous pyelographic studies with patient in horizontal position only did not reveal any pathology in upper urinary tract.

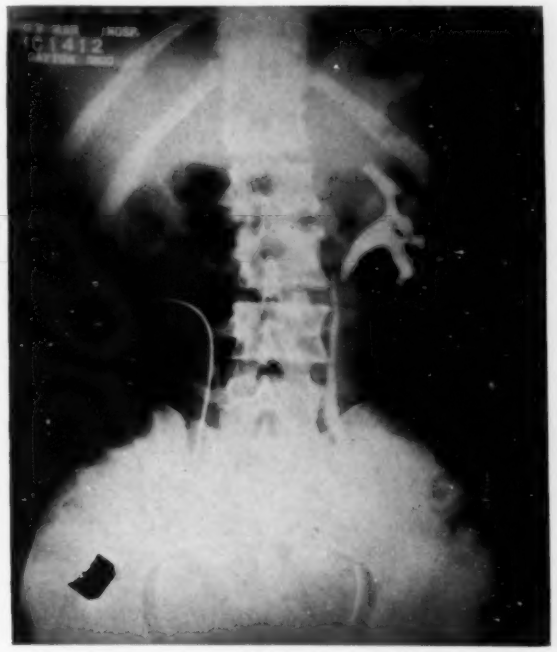


Fig 2*b*. Same case (G.B.). Pyelo-ureterogram reveals an acute angulation of the ureter opposite the third lumbar vertebra. At operation the acute angulation was found to be due to a fascial band encircling the ureter. Its removal resulted in clinical recovery.

Fig. 3*a*. D.M., aged thirty-two; admitted December 28, 1936, with complaint of pain in right side, frequency of urination and vesical tenesmus of three years' duration. Pyelogram in horizontal position demonstrated a grade 3 hydronephrosis. Cause undetermined.

Fig. 3*b*. Same case (D.M.). Pyelo-ureterogram in vertical position visualizes a pathological narrowing of the ureter at the ureteropelvic junction. At operation on January 8, 1937, a fascial band was found to be the cause of obstruction. Result: complete recovery.

FIG. 4*a*. B.K., aged twenty; admitted August 29, 1935, because of intermittent attacks of pain in the right quadrant of one year duration. Left kidney operation elsewhere two years previously. Details unobtainable. Pyelogram with patient in horizontal position reveals a dilated renal pelvis. Cause not determined.

FIG. 4*b*. Same case (B.K.). Pyelo-ureterogram in vertical position reveals the hydronephrosis to be due to an apparent obstruction at the ureteropelvic junction. At operation an anomalous blood vessel encircling the ureter was ligated which relieved the obstruction.

FIG. 5*a*. G.S., aged fifty-three; admitted July 4, 1936, with a history of intermittent attacks of pain in the left quadrant, associated with frequency of urination and dysuria. Treated elsewhere over a period of three years for pyelitis. Pyelogram in horizontal position reveals a grade 2 hydronephrosis. Cause of obstruction undetermined.

FIG. 5*b*. Same case (G.S.). Pyelo-ureterogram in vertical position visualizes an abnormal insertion of the ureter into the pelvis. At operation an anomalous vessel was found to encircle the ureter is such a way as to pull it cephalad and laterally. Ligation of vessel relieved obstruction.

Fig. 6*a*. E.T., aged twenty-six; admitted May 15, 1936, with a history of intermittent attacks of pain in the right hypochondrium over a period of six years. Extreme nervousness. Appendectomy three years previously failed to relieve the attacks. Horizontal pyelogram shows normal renal pelvis.

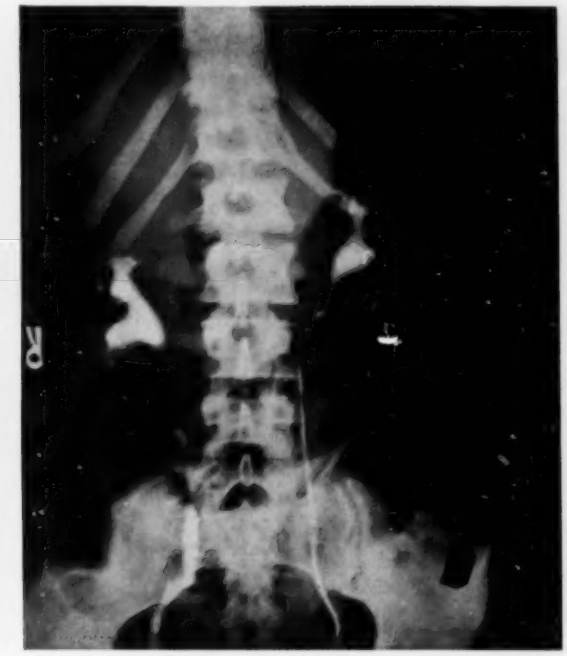


Fig. 6*b*. Same case (E.T.). Pyelo-ureterogram in vertical position reveals a definite angulation of the ureter opposite the third lumbar vertebra. At operation an adhesion was released which resulted in clinical recovery.

Fig. 7*a*. W.H., aged thirty-one; admitted July 1, 1936, with history of pain in right side, dysuria and irregular attacks of hematuria over a period of five years. Pyelogram normal.

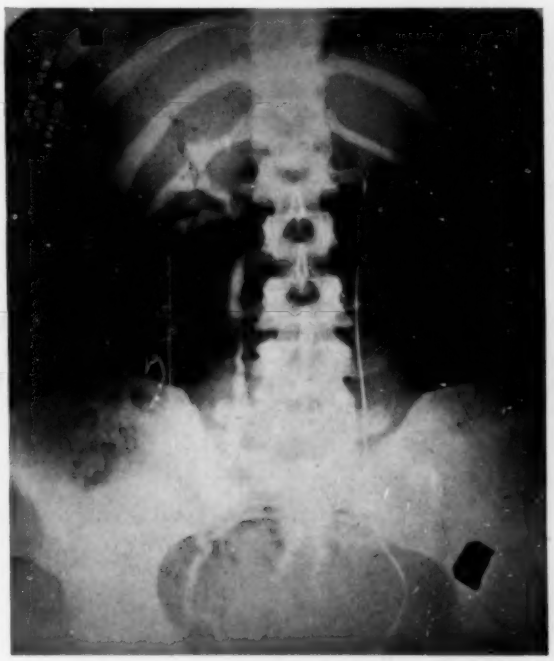


Fig. 7*b*. Same case (W.H.). Pyelo-ureterogram in vertical position visualizes an acute angulation in the pelvic portion of the ureter below the brim of the true bony pelvis. Operation revealed this obstruction to be due to an endometriosis.

FIG. 8*a*. H.D., aged twenty-five; admitted January 10, 1936, with complaint of pain in the right side occurring intermittently over a period of two years. Previous urograms reported normal. Pyelogram normal.

FIG. 8*b*. Same case (H.D.). Pyelo-ureterogram in vertical position visualizes an acute angulation of the ureter opposite the third intervertebral space. Nephropexy on January 13, 1936, has relieved patient of her pain.

FIG. 9*a*. J.D., aged forty-six; admitted August 10, 1936, with a history of irregular attacks of pain in her right iliac region occurring over a period of nine years. Pain usually relieved by lying down. Appendectomy six years previously with no relief of pain. Pyelogram reveals the kidney to be normal in position and a normal pelvis.

FIG. 9*b*. Same case (J.D.). Pyelo-ureterogram in vertical position reveals a third degree ptosis. Clinical recovery following a nephropexy.

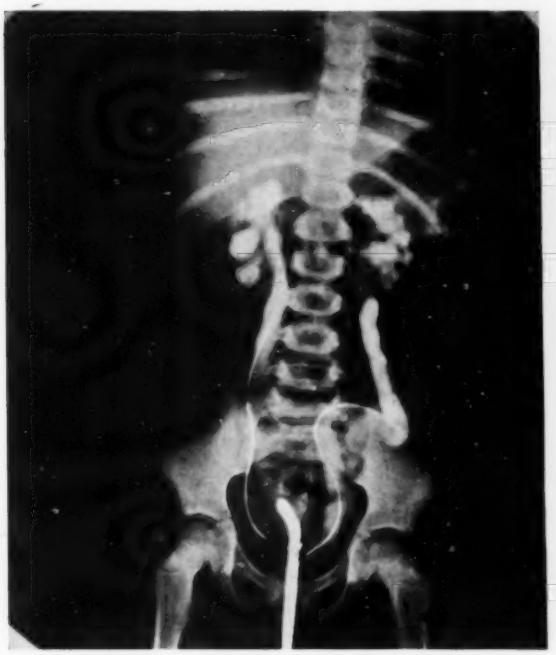


Fig. 10. N.W., aged five; admitted with history of enuresis and incontinence of three years' duration. Pyelo-ureterogram shows a bilateral hydronephrosis and megaloureters. Ureteral meatotomy resulted in improvement.

Fig. 11. E.M., aged fifty-one; admitted with complaint of pain in the right kidney region and extreme nervousness. Intravenous urograms done one year before were reported as showing no renal pathology. Pyelo-ureterogram in vertical posture visualizes a stricture of the ureter at the ureteropelvic junction.. Clinical improvement followed ureteral dilatations.

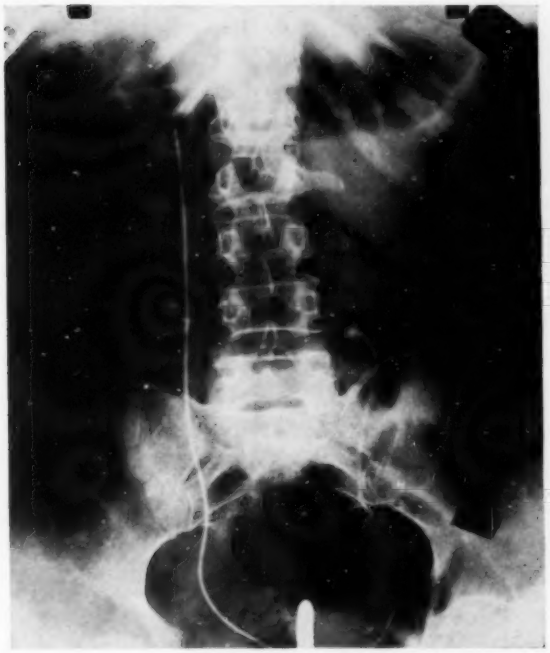


Fig. 12*a*. A.C., aged fifty-two; admitted with history of pain in left side, over a period of eighteen months. Horizontal study revealed probable calculus in left ureter.

Fig. 12*b*. Same case (A.C.). Presence of ureteral calculus verified by ureterogram.

FIG. 13. P.G., aged thirty; admitted April 8, 1936, with mass in left hypochondrium of three months' duration. Plain for period of years. Pyelo-ureterogram reveals atrophic kidney with megaloureter due to stricture at ureteral meatus. Recovery after nephrectomy.

FIG. 14. T.S., aged 28; admitted on August 4, 1936 because of pain in the right side of several years duration. Pyelo-ureterogram visualizes a stricture of the pelvic ureter on a level with the acetabulum improved following ureteral dilatations.

bands, anomalous vessels, extraureteral pressure, neoplasms, cysts, granuloma, chronic ureteritis, rupture into the duodenum and secondary calculus.

The differential diagnosis of stone, the most common cause of stasis, includes calcified myoma, teeth in dermoids, extrauterine pregnancy, prostatic stones, iliac and uterine vessel calcifications, deposits in ischial spine, sacroiliac ligaments, postoperative scars, coproliths, tuberculous glands, scybala, calcified ovary or cecum, fracture of transverse vertebral process, calcified parasites, phleboliths, enteroliths in appendix, sesamoids in obturator muscles, drugs ingested, old adhesions, calcified vas or mesenteric glands.

A few cases are here appended, with illustrations, many of which were not accurately diagnosed by the usual horizontal film, which exemplify the value of this routine and directed my efforts into this field.

SUMMARY

A routine is described which has been found valuable by the writer in diagnosis of obscure lesions of the urinary tract.

REFERENCES

1. BIEBERBACH, W. D., COOK, P. H., and GOODALE, R. H. Pyelo-ureteritis cystica, with report of case. AM. J. ROENTGENOL. & RAD. THERAPY, 1934, *31*, 778–783.
2. BRAASCH, W. F. Practical application of excretory (intravenous) urography. *J. Am. M. Ass.*, 1933, *101*, 1848–1852.
3. BÜTZLER, O. Zur Differentialdiagnose der Phlebolithen und Ureterkonkremente im Röntgenbild des kleinen Beckens. *Fortschr. a d. Geb. d. Röntgenstrahlen*, 1934, *49*, 253–262.
4. COLSTON, J. A. C. Primary tumor of the ureter. *Bull. Johns Hopkins Hosp.*, 1934, *55*, 361–386.
5. JACHES, L., and SWICK, M. Opaque media in urology, with special reference to new compound, sodium ortho-iodohippurate. *Radiology*, 1934, *23*, 216–222.
6. MOORE, T. D. Consideration of ureter in serial pyelograms. *South. M. J.*, 1934, *27*, 825–833.
7. SHAMBAUGH, P. Displacements of left kidney in diagnosis of tumors of left flank and abdomen. *Radiology*, 1936, *26*, 335–339.
8. TARTAGLI, D. Trauma vertebrale e calcolosi renale secondaria. *Radiol med.*, 1934, *21*, 814–819.

Vol. 40, No. 5

METASTATIC OBSTRUCTION OF THE ESOPHAGUS*

By CHARLES W. PERKINS, M.D.
NORWALK, CONNECTICUT

ACCORDING to statistics, carcinoma of the esophagus constitutes from 2 to 5 per cent of all cases of malignant disease. Cancer of that organ is far from being as rare as it was once believed to be. At present over two thousand deaths are caused by it annually in the United States. The death rate is higher in men than in women. The greatest incidence occurs between the ages of fifty and sixty-five. The most common site of location is the thoracic portion, next the cardiac portion, and less frequently the cervical region.

The pathological types are: (1) the bulky polypoid tumors which extend into the lumen and cause early obstructions; (2) the shallow ulcerating type with mediastinal involvement associated with backache and pain, although metastasis and obstructive symptoms are practically absent. However, a degree of difficult deglutition is present; (3) infiltrating scirrhous type with erosion of the wall and lumen producing fixation and obstruction;[1] (4) metastatic type secondary to carcinoma. The latter type is illustrated in this paper.

The roentgenographic and esophagoscopic methods are the principal means of examination. Particular emphasis should be placed on the roentgenoscopic examination with a thick barium solution. This method gives the most graphic outline of the anatomy and the best opportunity to study the mechanism of the esophagus in all positions. The esophagoscopic method has the added advantage in permitting an examination of the patency of the lumen and the removal of a small portion for histologic examination.

It did not seem wise to do an esophagoscopic examination on this patient due to her age, low vitality and the unnecessary discomfort that would result from such a procedure. The roentgenographic examination proved sufficient for a definite diagnosis.

The majority of such tumors come under types 3 and 4. Torek and Eggers in the United States and recently Tudor Edwards and G. Grey Turner in England have been fairly successful in accomplishing remarkable results in isolated cases.[1] However, there are only a few surgeons in the world sufficiently skillful to perform surgery of the esophagus.

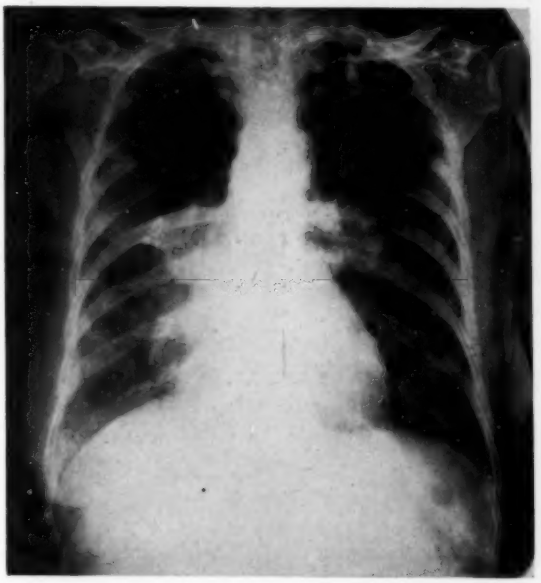


FIG. 1. March 16, 1936. Shows infiltration in right middle and lower lobes; left upper lobe.

In most cases the disease is well advanced when the diagnosis is made and the patients are in poor physical condition. Occasionally, in isolated cases and certain types of obstruction, a measure of success can be attained with palliative surgery, such as gastrostomy combined with roentgen therapy. The rest given the esophagus by a gastrostomy relieves the pain and helps to reduce the localized inflammation. Frequently, successful results are obtained by these methods.

* Read at the Fifth International Congress of Radiology, Chicago, Ill., Sept. 13–17, 1937.

Fig. 2. March 16, 1936. Left oblique view showing complete obstruction of the esophagus.

Complete regression of proved epidermoid carcinoma of the esophagus by irradiation has been reported in the literature. Guisez, using radium in tube or bougie by placing it in the lumen of the esophagus, claims palliative results in a large series of cases.[1] Holdfelder performed a post-mortem examination on a sixty-five-year-old patient with epidermoid carcinoma of the esophagus. This patient died of bronchopneumonia five months after roentgen therapy. The post-mortem showed the esophagus completely healed, with smooth walls and a scar at the site of the previous growth. A biopsy of a fragment of the wall failed to show any malignancy.[1] Stewart[2] has reported a case of carcinoma of the esophagus with good palliative results from roentgen therapy. Levitt claims palliative results in 6 cases treated with high voltage roentgen therapy.[1] Baum[1] has reported a case of esophageal gastric carcinoma successfully treated by protracted fractional roentgen therapy with a six-year survival.

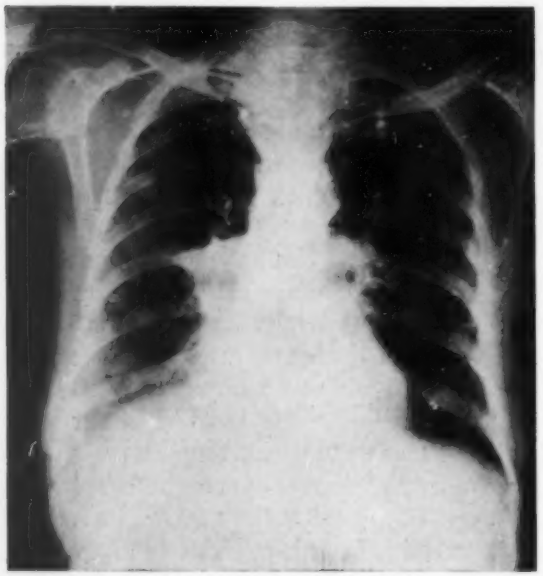


Fig. 3. June 20, 1936. Roentgenogram taken three months later after gastrostomy and roentgen therapy. The infiltrated area is diminished in size and density in the right and left lungs.

Fig. 4. June 20, 1936. Lateral oblique view at the same time which shows passage in the esophagus to the stomach.

A combination of surgery and irradiation with medium or high voltage seems to be the best method of treatment. However, what treatment is to be used will be largely determined by the number of clinical results which will be forthcoming in the immediate future.

REPORT OF CASE

M. B., widow, aged sixty-six; March 14, 1929. For three years the patient has had a dis-

charging ulcerated area in region of left nipple. This area gradually increased in size. No glandular involvement at the time either in the neck or axilla. The ulcerated area in the left nipple is 2 inches in diameter. The mass is attached to the deeper structures. Chest and heart normal. Patient in good physical condition. Urine negative. Operation: amputation of the left breast. Pathological examination of microscopic sections from the tumor show adenocarcinoma of the nipple ducts. This corresponds to Ewing's second type of Paget's disease where the nipple carcinoma invades the breast.

Fig. 5. October 5, 1936. Roentgenogram taken eight months later after another series of roentgen therapy. Infiltration less dense than at time of previous examination.

On March 16, 1936, the patient was referred to me by Dr. Zweben of Norwalk. Eight months previously she began to experience difficulty in deglutination. At present she is not able to swallow anything and all the food regurgitates. Dry cough. Patient is very much emaciated and practically starving to death. No family history of cancer. No previous illness except the operation on the breast. The patient was able to come to the office for roentgen examination. Parents and grandparents lived to be very old. Grandparents were said to have lived to be 116 and 114, of German Peasant stock, parents both over ninety.

Roentgenoscopic and roentgenographic examination of the chest showed irregular areas of infiltration progressing from the right hilus

Fig. 6. December 18, 1936. Roentgenogram taken ten months later. Growth in lungs about the same with passage open in the esophagus.

outward for a distance of 7 cm., and downward for 9 cm. The left hilus shows infiltration upward and into the upper lobe of the lung for a distance of 7 cm. The esophagus is obstructed opposite the seventh dorsal vertebra and none of the contrast medium was able to pass through. However, there may be a slight seepage at times.

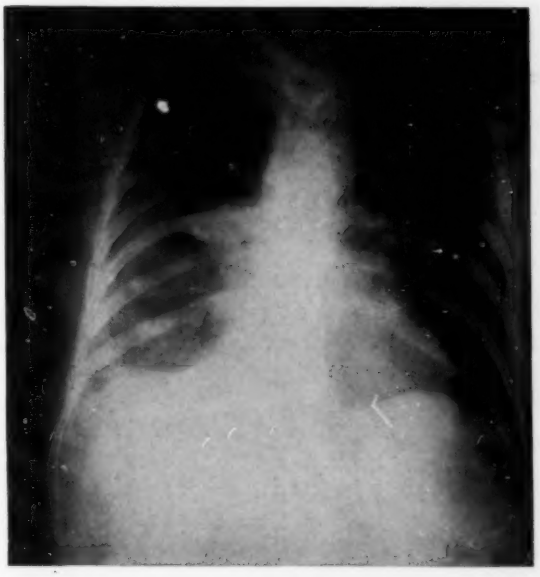


Fig. 7. December 18, 1936. At ten months after original examination, infiltration less than at eight months.

The heart showed good action and impulse.

The above findings point to an extrinsic tumor growth, metastatic in character involving the lungs and bronchi.

Urine examination was negative. Red blood cells, 5,280,000; leukocytes, 9,400 with 81 per cent polymorphonuclears, 10 per cent lymphocytes and 9 per cent transitionals; hb, 100 per cent.

Fig. 8. Photograph taken February 8, 1937, two weeks before the death of the patient.

On March 21, 1936, gastrostomy was performed under local anesthesia at the Norwalk Hospital by Dr E. J. Tracey and Dr. Zweben and a tube inserted for feeding. After operation the patient gradually increased in strength and appetite by tubal feeding. Patient was able to go to the hospital roentgen laboratory during the following month. A series of roentgen treatments was given to the anterior, lateral and posterior aspects of the chest over the growth. The amount of treatment was 2,200 r, 200 kv., 4 ma., 50 cm. distance, with 1 mm. Al and 0.5 mm. Cu as filter. Period of treatment one month. The patient was discharged from the hospital on June 6, 1936, much improved in health and able to take liquid and soft food by mouth. Gained 25 pounds in weight.

Following her return home she was examined at my office on June 10, 1936. The examination showed the infiltrated growth much reduced in size and density. Liquid food passed through the esophagus without difficulty, although the portion in the vicinity of the seventh dorsal vertebra showed constriction and dilatation. Another series of treatments was given at my office over the chest between September 4 and October 16, 1936. Practically the same dosage was given as in the first series. The examination at this time showed the growth reduced in size and less dense as compared with the examination in June. Food was passing more easily through the esophagus than at the time of previous examination.

The patient was not seen in the office until December 3, 1936, when another roentgen examination revealed the size of growth and passage inthe esophagus about the same as it was at the time of examination in October. Treatments were continued until February 15, 1937. Patient at time of visit in February began having expectoration of some blood-tinged sputum which was examined microscopically but did not show any malignant cells.

The woman died of inanition and exhaustion in the latter part of February, 1937. There was no increase in size of the mediastinal infiltration and no evidences of metastasis elsewhere.

Comment. While the gastrostomy relieved the inflammation and irritation arising from the infiltrating mass surrounding the esophagus the roentgen treatment reduced the growth which was pressing on the esophagus and allowed the patient to take liquid and soft food through the mouth. She was given almost a year more of life without serious discomfort and much relief from pain. The patient would undoubtedly have died of starvation in a short while if palliative measures had not been instituted. It is, therefore, another step forward in the relief and treatment of metastatic cancer. Any progress gained from time to time will ultimately lead to more definite results.

REFERENCES

1. Baum, S. M. Esophageal-gastric carcinoma successfully treated by protracted fractional x-ray. *Radiology*, 1936, *27*, 58–62.
2. Stewart, W. H. Eastern Conference of Radiologists, January, 1937.

VOL. 40, NO. 5

THE CONTROL AND CALIBRATION OF ROENTGENOGRAPHIC APPARATUS*

By CHARLES WEYL, S. REID WARREN, JR., *and* DALLETT B. O'NEILL
PHILADELPHIA, PENNSYLVANIA

THE development and maintenance of proper apparatus and technique for the routine production of comparable, high quality roentgenograms presents many complicated problems. Any attempt to solve these problems in a scientific manner, so that their solutions may be generally applicable, requires accurate knowledge and precise control of the technical factors involved. Previous investigations of the problems associated with chest roentgenography have outlined the scope of these problems[1] and the important technical factors to be specified and controlled.[2] It must be noted that these same factors are assigned in the specification of technique in any other branch of roentgenography. It is of fundamental importance that apparatus and methods used for calibration and control provide the greatest possible accuracy.

It is the purpose of this paper to discuss the problems which arise in the calibration and control of roentgenographic equipment and to describe the apparatus and methods used in their solution.

The high voltage generating equipment most generally used at the present time to produce satisfactory roentgenograms is the full wave rectifying type with a capacity of 100 kv. (peak), 100 ma., to 100 kv. (peak), 500 ma. With such equipment installed and supplied by an adequate power transformer and line[11] the resultant roentgenogram of a given subject will depend upon:

1. Exposure time.
2. Roentgen tube current.
3. Roentgen tube voltage.
4. Focal spot-film distance.
5. Roentgen tube.
6. Intensifying screens and cassettes.
7. Roentgen films, and processing materials and procedure.

Each of these factors will be discussed individually below and an exact method of specifying technique will be presented.

Exposure Time. The time of exposure is usually controlled by a switching device in the low tension circuit. This device, the timer, closes the circuit upon operation of a push-button or foot-switch and automatically opens the circuit after a predetermined time interval. The exception to this general method is encountered in condenser discharge apparatus in which the time of exposure is determined by the rate of discharge of the condenser through the roentgen tube, this rate being controlled by the roentgen tube cathode current.

It is possible to consider the quantitative specification of exposure time from two points of view. The exposure time may be regarded as that time interval during which the high tension generating equipment is operating and supplying a rectified high potential to the roentgen tube. Or it may be regarded as the time, or sum of times, during which radiation reaches the roentgen film. This second possibility has much to commend it as the more fundamental physical factor but the first possibility is eminently more practical. The time of exposure is almost universally specified from the electrical viewpoint, because the measurement and predetermination of exposure time from the point of view of the film would be extremely difficult. However, while expediency demands specification of technique in terms of the electrical time of exposure, it is imperative to remember that *it is not a fundamental quantity*. For any particular subject there may be de-

* This investigation was conducted at the Moore School X-ray Laboratory, University of Pennsylvania, under a grant by the National Tuberculosis Association.

termined experimentally a roentgen tube voltage below which the radiation produced by the tube will not reach the film under this subject. For an average adult chest this threshold voltage is approximately 35 kv. (peak) with normal values of roentgen tube current, exposure time and focal spot-film distance. It is apparent that the same electrical exposure times will not result in equal times of effective photographic exposure with the same subject when the roentgen tube is energized by such widely different voltage wave-forms as those produced by single-phase full-wave rectified,[12] three-phase full-wave rectified,[13] and condenser-discharge apparatus.[14] Among different generators of the same type these variations are not so striking but may still be appreciable. It is important to note, therefore, that in assigning as the time of exposure the time of electrical operation there is specified a factor of convenience, not one of fundamental physical significance with regard to the finished roentgenogram.

The fundamental requirement of the timer is accurate control of the time interval during which the primary circuit is closed. The timers in general use are the clutch type, which may or may not be operated by a synchronous motor, and the synchronous impulse type which is driven by a synchronous motor and may be adjusted to make and break the circuit at instants of zero current, thus providing an integral number of half-cycles. The clutch timer under the best conditions, operated by a synchronous motor and carefully adjusted, has an inherent error of approximately $\pm 1/120$ second. This error restricts the use of this type of timer to techniques requiring an exposure time of no less than $\frac{1}{4}$ second, since for any time less than $\frac{1}{4}$ second an error of $1/120$ second is appreciable. For exposure times greater than $\frac{1}{4}$ second the synchronous clutch timer should be adequate since the error is too small a percentage of the total time to have practical effect. For exposure times less than $\frac{1}{4}$ second precise control requires the use of a synchronous impulse timer.

When using a synchronous impulse timer for short exposure times it is important from several points of view to have the timer properly phased to make and break the primary circuit at instants of zero current. If the timer makes and breaks the circuit at instants when the current is not zero, transients may occur which render precise electrical calibration and constant roentgenographic output impossible. The

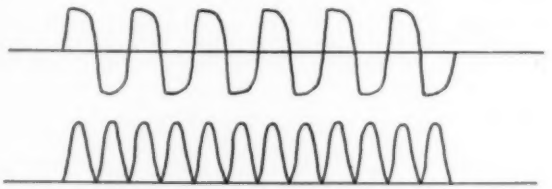


Fig. 1. Oscillographic tracing of roentgen tube voltage (below) and secondary current (above) for four-valve roentgenographic apparatus with properly phased impulse timer. Roentgen tube voltage, 85 kv. (peak); average roentgen tube current, 100 ma.; exposure time, 0.1 second.

presence of such transients was demonstrated by the following tests. A four-valve roentgenographic apparatus, with adequate supply line and transformer, was used with a synchronous impulse timer to produce exposures of 0.1 second with an average roentgen tube current of 100 ma. The timer was adjustable in the sense that the contacts could be made to operate at any desired phase of the primary current. This device was first adjusted to produce twelve identical half-cycles. This was checked by making oscillograms[3] of the roentgen tube voltage and current. These oscillograms are shown in Figure 1.* The sphere gap reading and the oscillograph calibration gave 85 kv. (peak) as the maximum roentgen tube voltage. Next, the timer was adjusted to make and break the primary circuit 90 electrical degrees later than that shown in Figure 1. The circuit

* It is to be noted that the secondary current recorded in all oscillograms reproduced in this paper is the alternating current at the grounded center-tap of the secondary of the high tension transformer. The actual roentgen tube current differs from this recording only in that alternate half-cycles are inverted, because of the rectifying system.

was closed by the timer contacts at this setting but was opened by a manually operated series switch to prevent burning of the timer contacts by the arc which would result from breaking the circuit at an instant when the current was not zero. The oscillograms of this exposure are shown in Figure 2.* The transients at the beginning of the exposure rise to over 104 kv. (peak). *The sphere gap broke down at every exposure when adjusted for 105 kv. (peak).* Further tests showed that by adjusting the phase of the timing mechanism any sphere gap readings between 85 kv. (peak) and 105 kv. (peak) could be obtained at will. This phenomenon has been found to be absent at higher roentgen tube currents. The value of current at which it disappears is critical and depends upon the characteristics of the apparatus. There may also be observed an extra half-cycle of lower voltage and current at the end of the exposure,

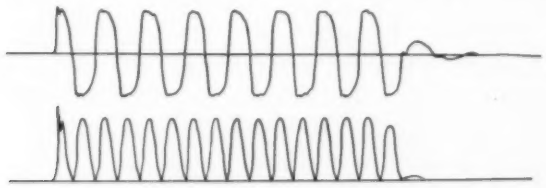


Fig. 2. Oscillographic tracing of roentgen tube voltage (below) and secondary current (above) for four-valve roentgenographic apparatus with impulse timer contacts advanced 90 electrical degrees from the correct phasing shown in Figure 1. The exposure was terminated manually. Roentgen tube voltage, 105 kv. (peak) for first peak, 85 kv. (peak) for succeeding half-cycles; average roentgen tube current, 100 ma.

produced by the arc, which also occurs when an improperly phased timer is used to open the circuit. The latter effect is variable and uncontrollable and makes impossible the accurate predetermination of exposure. The transient voltage peak which was seen at the beginning of the exposure will also affect this accuracy and in addition will tend to produce grid lines if a Potter-Bucky diaphragm is used. The high intensity pulse of radiation produced by this peak occurs during such a short time that the grid is effectively stationary for its duration and a sharp shadow of the grid will appear on the film. More important, however, is its effect upon voltage calibration by means of a sphere-gap. In making such a calibration the roentgen tube voltage may appear to have values differing by as much as 20 kv. (peak) for the same setting of the

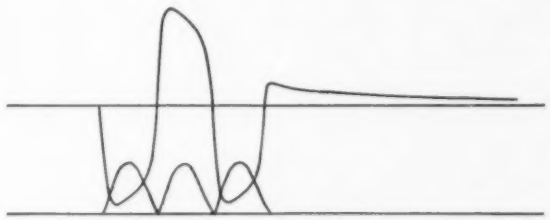


Fig. 3. Oscillographic tracing of roentgen tube voltage (below) and secondary current (above) for four-valve roentgenographic apparatus with impulse timer. Roentgen tube voltage, 80 kv. (peak); milliampere-seconds during 1/40 second exposure, 2.7 ma-sec.; milliampere-seconds during subsequent discharge, 0.8. ma-sec.; ballistic milliampere-second meter reading, 3.5 ma-sec.

apparatus at different phases of the timer. Because of these phenomena it is imperative that a synchronous impulse timer, properly phased, be used for short exposure times both for calibration and for routine roentgenography.

Because of another transient effect the use of an even number of half-cycles for routine exposure is necessary to avoid errors in determining the exposure. A series of exposures, each comprising an odd number of half-cycles, may result in readings of a ballistic milliampere-second meter bearing no relation to the radiation outputs during the exposures. The phenomenon which causes this is illustrated by the oscillographic tracing (Fig. 3). After the exposure is completed there is a long (about 0.1 second) approximately exponential discharge of current through the roentgen tube and the milliampere-second meter. The total milliampere-seconds indicated by the meter was found to be divided as follows:

* See discussion under *Roentgen Tube Voltage* concerning the type of resistors used in the recording system for obtaining oscillograms of transient voltage phenomena.

Milliampere-seconds during 1/40 second exposure	2.7
Milliampere-seconds during subsequent discharge	0.8
Total milliampere-seconds (meter reading)	3.5

The discharge after the primary circuit is broken is due apparently to the collapse of a magnetic field in the core of the high tension transformer. This field is negligible after an exposure comprising an even number of half-cycles (i.e., an integral number of complete cycles); it is appreciable after an exposure of an odd number of half-cycles. Such exposures should therefore be avoided. This dependence of milliampere-seconds upon the previous experience of the high tension transformer has been noted also in single-valve roentgenographic apparatus.[4]

The calibration of the timing mechanism may be accomplished most accurately oscillographically in the manner referred to above. This method, however, requires equipment not usually available in the roentgenographic laboratory. A simple means of making the calibration is the use of a spinning lead disc with a small hole, approximately $\frac{1}{8}$ inch in diameter, near the periphery. A dot corresponding to this hole will be recorded on the film for the pulse of radiation accompanying each half-cycle. Since the disc is rotating the hole will be in a different position for each pulse and the total exposure will be represented by a number of dots equal to the number of half-cycles during which the apparatus is operating. This system of calibration is useless for condenser-discharge equipment but may be used for three-phase apparatus if the speed of rotation of the disc is constant and known. The time of exposure may then be calculated from the measurement of length of the arc recorded through the hole by the three-phase exposure.

Roentgen Tube Current. The current which flows through the roentgen tube during an exposure is usually pulsating direct current. A rigorous specification of such a current requires a complete quantitative description of the wave-form. For routine work this is entirely impractical and it becomes necessary for convenience to use a simpler method, even if it is less precise. Any one of the peak, average or root-mean-square values of this current might be specified and on the basis of their relationships to the roentgenographic effect there is no evidence favoring the choice of any one. Because of ease of measurement the average value is almost universally used in the specification of roentgen tube current.

For exposures of approximately one second or more the average value of the roentgen tube current may be measured with a milliammeter connected in the high tension lead to the roentgen tube. If the exposure is shorter than one second the current cannot be measured with a milliammeter, since the moving coil and pointer of the meter require approximately this time to attain a correct steady deflection. For short exposures it is necessary to connect in the high tension circuit a ballistic milliampere-second meter, the maximum deflection of which is proportional to the product of the average roentgen tube current and the time of exposure. From the reading of such a meter in milliampere-seconds and knowledge of the exposure time in seconds the average value of the current in milliamperes may be computed. Both the milliammeter and the milliampere-second meter are necessary in a general roentgenographic laboratory for accurate calibration and control of the roentgen tube current. The ranges of these instruments depend on the capacity of the equipment and the techniques being used, but for precise measurement it is essential that the scales be no less than 6 inches in length and that the meter be mounted so that it is clearly visible to the operator in the control booth.

The magnitude of the roentgen tube current is determined by the temperature of the roentgen tube cathode and the value of roentgen tube voltage. The dependence upon voltage is usually slight, although in a type of tube recently introduced this

effect is of considerable importance and in any case must be considered for accurate control of current over a wide voltage range. However, a small change in cathode temperature will produce a very great change in roentgen tube current, and since the temperature of the cathode is determined solely by the cathode current it is imperative that this cathode current be controlled with the greatest practicable accuracy. The extremely critical dependence of roentgen tube current upon cathode current is shown in Figure 4, from which it may be seen that a change of 5 per cent of the cathode current resulted in a variation of 50 per cent or more of the roentgen tube current for a commonly used line-focus roentgenographic tube. This phenomenon, studied in minute detail by Richardson and others during early experiments on thermionic emission, is inherent in the operation of all roentgen tubes. For high current roentgenography careful attention must be given to every detail of the cathode

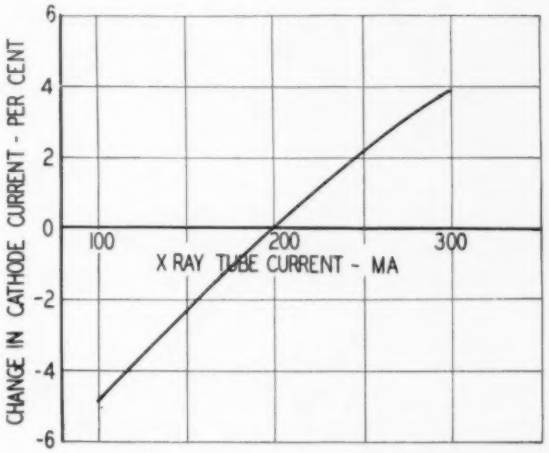


Fig. 4. Change in average roentgen tube current for small changes in cathode current for line focus roentgenographic tube. Cathode current, 7.10 amperes for average roentgen tube current of 200 ma.

circuit. The important items to be considered are:

1. The cathode circuit input voltage.
2. The cathode current control.
3. The cathode current ammeter.
4. The conductors used in the cathode circuit.

If the cathode circuit input voltage is obtained directly from a winding on the autotransformer, the roentgen tube voltage and current will vary during each exposure, as shown by the oscillograms in Figure 5. The temperature of the cathode at the beginning of the exposure is determined by the input voltage and the adjustment of the cathode current control. As soon as the exposure begins there is a drop in input voltage caused by the flow of current through the supply transformer, line and autotransformer. This drop in voltage produces an immediate decrease in cathode current, which is followed by a gradual decrease in cathode temperature.

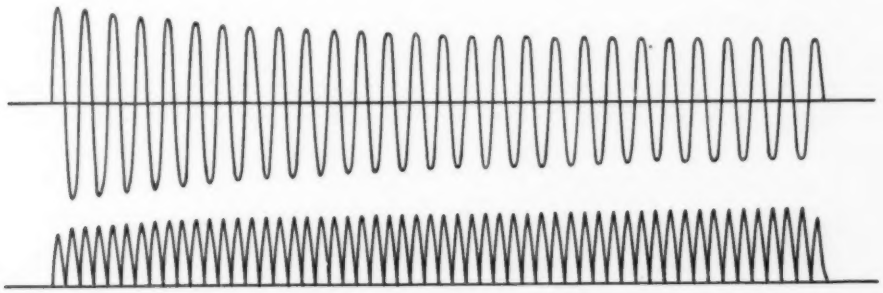


Fig. 5. Oscillographic tracing of roentgen tube voltage (below) and secondary current (above) for four-valve roentgenographic apparatus without stabilizer. Roentgen tube voltage 58 kv. (peak) for first complete half-cycle, 68 kv. (peak) for last complete half-cycle; average roentgen tube current, 140 ma. for first complete half-cycle, 100 ma. for last complete half-cycle; exposure time (manually controlled), approximately 55/120 second. The line voltage dropped 10 volts during this exposure.

As the temperature of the cathode becomes less it produces a continuous decrease in roentgen tube current and consequent increase in roentgen tube voltage. These continuous changes, shown in Figure 5 for a line voltage drop during exposure of 10 volts, cease after the cathode temperature has reached a stable equilibrium value and the roentgen tube voltage and current are constant after that time. It will be seen later that the presence of these effects may make accurate calibration impossible. Another frequently encountered difficulty is the variation of cathode current produced by random changes in line voltage. Since these changes are unpredictable both as to magnitude and time of occurrence their presence seriously handicaps any attempt at precise control.

Many roentgenographic machines have been equipped with devices which stabilize the cathode current more or less effectively. These devices may be divided into three classes:

1. Electromechanical stabilizers connected in the high tension circuit.
2. Cathode current boosters connected in the primary of the cathode circuit.
3. Automatic voltage regulators connected between the supply voltage and the cathode current control. These devices are commonly called static stabilizers.

The high tension stabilizer usually consists of a system of relays and resistors. The relay coils are connected in series with the high tension circuit so that the roentgen tube current passes through them. The relay armature contacts are connected to the resistors which, in turn, are connected in series with the cathode heating circuit. The minimum current for which the main relay will operate may be varied by changing the spring tension on the relay armature. When the current exceeds this minimum value the relay operates and a resistance is connected in series with the cathode. The cathode subsequently cools, decreasing the roentgen tube current. This decrease causes the relay to open, short circuiting the auxiliary cathode resistance and thereby increasing the cathode current. The roentgen tube current increases and the whole cycle is then repeated. This cycle of operation may recur several times per second, depending upon the line voltage drop, the adjustment of the stabilizer, and the type of roentgen tube. The oscillographic tracings (Fig. 6) show the resultant roentgen tube current and roentgen tube voltage variations for a line voltage drop during exposure of 10 volts. These variations render any calibration inaccurate and for short exposures and high currents the inaccuracies are of practical importance. Therefore, while having some advantages for long exposures, *electromechanical stabi-*

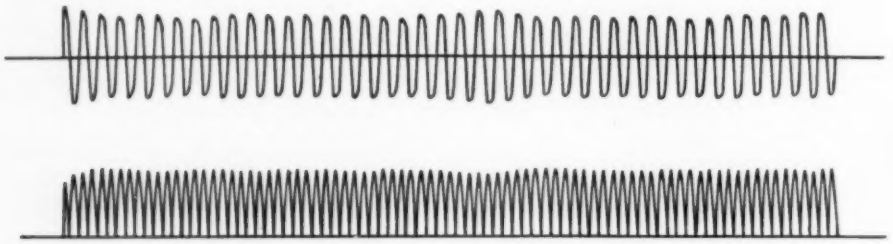


FIG. 6. Oscillographic tracing of roentgen tube voltage (below) and secondary (above) for four-valve roentgenographic apparatus with high tension stabilizer. Roentgen tube voltage, 72 kv. (peak) maximum, 67 kv. (peak) minimum; average roentgen tube current, 75 ma. for entire exposure, 84 ma. for maximum half-cycles, 69 ma. for minimum half-cycles; exposure time (manually controlled), approximately 82/120 second. The line voltage dropped 10 volts during this exposure.

lizers connected in the high tension circuit should not be used for short exposure roentgenography.

The commonly used cathode current booster comprises a specially designed transformer so connected that whenever roentgen tube current flows the cathode current is automatically increased to compensate for the drop in input voltage to the roentgenographic apparatus. If the line voltage is constant (except for the drop caused by the exposure) this booster system can be adjusted to maintain constant roentgen tube current. However, even the best supply systems normally vary from 2 to 5 per cent and changes of this order may occur between the time of adjustment of the apparatus and the exposure. It was previously shown that variations of this order will produce excessive changes in roentgen tube current. *The booster alone does not correct such changes and is not recommended unless a primary circuit cathode current stabilizer is also installed. Only under this condition and when used for the cathode circuit of the valve tubes is the booster advantageous.*

The most commonly used primary circuit cathode current stabilizers consist of specially designed transformers, chokes, and condensers, connected to form a four-terminal network. If the two input terminals of this network are connected to a source of *sinusoidal* alternating current and the output terminals are connected through the cathode control to the primary winding of the cathode heating transformer, the root-mean-square cathode current remains substantially constant for wide variations in the supply voltage. One such stabilizer working at rated load showed a maximum change in output voltage of 0.3 per cent as the input voltage was varied from 200 volts to 240 volts. The actual changes in line voltage encountered in practice are usually less than those used in this test. It is important to note that this type of stabilizer compensates for voltage drop during exposure *and* sudden changes in line voltage due to outside sources. An example of the resultant constancy of roentgen tube voltage and roentgen tube current is shown in the oscillographic tracing (Fig. 7). The line voltage dropped 10 volts during this exposure.

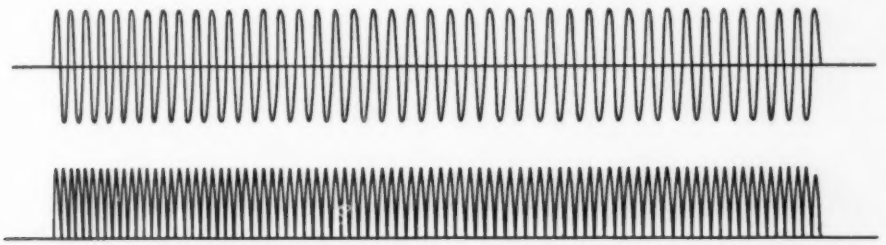


Fig. 7. Oscillographic tracing of roentgen tube voltage (below) and secondary current (above) for four-valve roentgenographic apparatus with primary circuit cathode current stabilizer. Roentgen tube voltage, 72 kv. (peak); average roentgen tube current, 100 ma.; exposure time (manually controlled), approximately 85/120 second. The line voltage dropped 10 volts during this exposure.

It is definitely necessary to use a primary circuit cathode current stabilizer to insure precision in the control and calibration of roentgenographic apparatus.

With the cathode circuit input voltage properly stabilized, the current will depend only upon the adjustment of the cathode current control.* Such controls usually consist of choke coils, the im-

* Although the root-mean-square output voltage of a cathode current stabilizer remains nearly constant when the input voltage is varied over a range of ±10 per cent of the nominal input voltage, the wave-form of the output is not sinusoidal and may vary when the input voltage is changed. Thus the constancy of the cathode current *may* be influenced by the characteristics of the cathode current stabilizer; the cathode current control and the cathode heating transformer. Tests of apparatus in a number of sanatoria and hospitals indicate that such effects seldom have practical significance. Nevertheless a more detailed study of the problem is contemplated.

pedance of which may be varied by changing the length of an air gap in the core of the choke coil, or variable resistances. The choke or resistance and the mechanical control assembly should be so designed that a change of 90 circular degrees in the position of the control knob produces a change of 2 per cent or less of the cathode current, within the range used for roentgenography. This, in combination with the ammeter described below, permits accurate predetermination of the roentgen tube current.

In addition to controlling accurately the cathode current, it is necessary to measure this current with equal accuracy. This is possible only if the cathode current is measured by means of a good ammeter connected in series with the roentgen tube cathode in the high tension circuit. Ammeters connected in the primary circuit may not be satisfactory, since variations in temperature of circuit parts and in contact resistance may prevent any fixed correlation of cathode current and primary current. On the other hand, high tension cathode current ammeters are often mounted in a position which makes accurate reading impossible and the meter scales are designed so that small changes in current are not observable. The ammeter should not be of the suppressed zero type since the deflections of such meters frequently are not accurate. There should be steps of 0.05 ampere between minor scale divisions, which should be separated by at least 1.5 mm. over the range for roentgen tube currents greater than 100 ma. The pointer of the instrument should be narrow and the meter should be provided with a mirror below the scale to minimize errors due to parallax. If such a meter is mounted at approximately eye level within 18 inches of the observer the value of the cathode current may be read accurately.

Since small changes in cathode current produce important changes in roentgen tube current it is necessary to design carefully all of the conductors and their electrical connections in the cathode circuit. This is particularly important in the high tension circuit. High tension switches should consist of heavy copper blades and spring jaws since other types of contacts may introduce resistances into the circuit and if these contact resistances are not constant the roentgen tube current will not be stable. The connections from the overhead system to the cathode terminals of the roentgen tube are often insecure and unsatisfactory. Heavy contact sockets should be used at the cathode terminals. Wires should be soldered or strongly bolted to the socket. If flexible leads and reels are used, the reels should be made of non-magnetic material and the wire should consist of heavy, stranded, well insulated wire. These wires should be soldered to the terminals of the overhead system.

The calibration of roentgen tube current involves the measurement of this current at known values of roentgen tube voltage and cathode current. This measurement may be made with the high tension milliammeter for currents sufficiently low to permit an exposure of one second or more. For high values of roentgen tube current the measurement is made with the ballistic milliampere-second meter, using an impulse timer to time the exposure. Since this calibration is dependent upon the roentgen tube voltage a detailed discussion will be reserved until the methods of measuring this voltage have been described.

Roentgen Tube Voltage. The problem of specifying the pulsating direct voltage applied to the roentgen tube is similar to the problem previously discussed with respect to roentgen tube current. Since a rigorous specification would involve determination and description of the complete wave-form, it is necessary to specify this voltage in terms of a simple and practical method of measurement. Until recently the only convenient way to measure roentgen tube voltage was by means of a sphere gap and as a result the peak value of the voltage is almost always designated in the specifi-

cation of roentgenographic technique. The relation of roentgen tube peak voltage to roentgenographic exposure is extremely variable over a group of high voltage generators of different types, such as single-phase full-wave rectified,[12] three-phase full-wave rectified,[13] and condenser-discharge.[14] Even with the same apparatus the wave-form of the voltage produced at different roentgen tube currents may be very different, as shown by Figure 8 in which are reproduced oscillographic tracings of voltage wave-forms at 10 ma. and 100 ma. for a mechanically rectified roentgenographic apparatus. Again let it be emphasized that the roentgen tube peak voltage is a factor chosen for convenience and cannot be considered to have any fixed relation to the roentgenographic result.

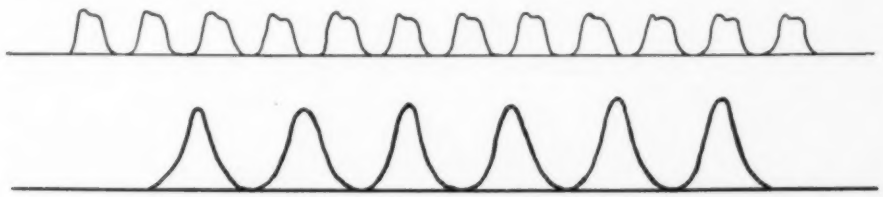


FIG. 8. Oscillographic tracing of roentgen tube voltage for a mechanically rectified roentgenographic apparatus at average roentgen tube currents of 10 ma. (above) and 100 ma. (below).

The voltage supplied to the roentgen tube is usually controlled by switches connected to taps of the autotransformer. By the use of these switches the voltage applied to the primary of the high-tension transformer is varied, with a resultant variation of roentgen tube voltage. Modern roentgenographic practice requires that this control system be so designed as to permit the roentgen tube voltage to be varied in steps of *1 kilovolt or less*.

The roentgen tube voltage at a given roentgen tube current depends solely upon the voltage supplied to the primary of the high tension transformer during the exposure. However, it is necessary to determine the roentgen tube voltage before the exposure begins, so that measurement of the primary voltage during exposure, besides being extremely difficult with short exposure times, would be of little practical value. As a result, less direct methods for the determination of roentgen tube voltage have been devised. The three generally employed devices and methods are:

1. A pre-reading voltmeter connected between the voltage selecting switch and one end of the autotransformer secondary. A calibration of roentgen tube voltage against pre-reading voltmeter readings is made at each required roentgen tube current.

2. A line voltage compensating device and an indicating voltmeter permit changes of the number of connected turns on the autotransformer primary to compensate for variations of line voltage. Adjustment of the compensating device to maintain the same reading of the indicating voltmeter guarantees the same voltage at all times on each tap of the voltage-selecting switch. A calibration of roentgen tube voltage against tap numbers is made at each required roentgen tube current.

3. A line voltage compensating device and an indicating voltmeter permit changes of the number of connected turns on the autotransformer primary to compensate for both variations of line voltage and the voltage drop during exposure. Adjustment of the compensating device to obtain the predetermined reading of the indicating voltmeter for each given roentgen tube current will result in an approximately fixed relationship between autotransformer taps and roentgen tube voltage. The taps may be marked in peak kilovolts with an accuracy of 2 kv. (peak) over the range of roentgen tube currents. A calibration of voltmeter readings against roentgen tube current is made. It should be noted that by maintaining a constant voltmeter reading this type of apparatus may be used with the method described in No. 2 above.

Any one of the three methods described above may be used for the control and predetermination of roentgen tube voltage if sufficient care is taken in the design of the system chosen. It is important that the voltmeter be of the free zero type with a fine line pointer and mirror. The scale should be at least 4 inches in length and marked in volts, with minor divisions separated by not more than 2 volts. If this meter is used in conjunction with a line voltage compensating device the particular value, or values, at which the voltage must be maintained may be marked with a differently colored line. Any line voltage compensating device which is used must permit changing the line voltage in *steps not greater than 3 volts*. Regardless of the method used, the voltage selecting switch connected to taps on the secondary of the autotransformer must provide variation of roentgen tube voltage *in steps not exceeding 1 kilovolt*. And in the use of any system it is extremely important that the required calibration be made with the greatest possible accuracy and that it be made *after installation and in addition to the calibration made at the factory*.

The measurement of roentgen tube voltage may be made by one of two general methods. The voltage may be measured directly by means of a sphere-gap at high potential, or a high resistance voltage divider connected across the roentgen tube may be used to obtain a fixed fraction of the tube voltage at low potential where it may be measured in a number of ways and the actual value of the roentgen tube voltage computed from the known ratio.

The sphere-gap is used to measure the peak value of roentgen tube voltage. On long exposures this may be done by decreasing the separation of the spheres until spark-over occurs. On short exposures it is necessary to fix the distance between the spheres and then make the exposure. The peak value is measured by the greatest distance at which spark-over will occur under these conditions. Such a measurement on short exposures will be accurate only if the peak value of the voltage does not change during the exposure. From previous discussion under *Roentgen Tube Current* and *Exposure Time* it is seen that the voltage is constant only if a primary circuit cathode current stabilizer and a correctly phased synchronous impulse timer are used.

The spheres used for measuring voltages in the roentgenographic range may be from 5 cm. to 15 cm. in diameter. The calibration of the sphere-gap should be based upon standards of the American Institute of Electrical Engineers, with proper correction for differences in air density. In connecting the terminals of the sphere-gap to the overhead system care should be taken to prevent the sphere-gap current from flowing through the current measuring instruments. In order not to overload the impulse timer a resistance of at least 1 megohm should be connected in series with each terminal of the sphere-gap. Molded carbon resistors are not satisfactory for this purpose and it is convenient to use a pyrex tube filled with tap water. A water column $\frac{1}{4}$ inch in diameter and 12 inches long will usually provide adequate resistance.

The alternate method of measuring roentgen tube voltage requires the use of a high resistance voltage divider. This resistance should be of such value as to impose no appreciable load on the high voltage generating apparatus and it should have sufficiently low inductance and capacitance so that the wave-form of the current which flows through it will not depart appreciably from the wave-form of the voltage across which it is connected. This latter condition is particularly important when measurements are to be made of transient voltage surges such as that shown in Figure 2. Over the range of roentgenographic voltages a resistance of 100 megohms may be used without drawing more than 1 milliampere from the generator. This resistance may be conveniently obtained by connecting in series one hundred small resistor units of 1 megohm each.

This resistance is divided in two parts of 50 megohms each, and a small resistor of 100,000 ohms is connected in series with and between the two larger resistances. When the voltage divider so constructed is connected across the roentgen tube terminals and an exposure is made, the voltage across the 100,000 ohm resistance at any instant is a fixed fraction of the voltage being applied to the tube at that instant. Having computed this fraction[5] it is only necessary to measure the small voltage across the 100,000 ohms and calculate the roentgen tube voltage. In making such a measurement one side of the small resistance should be grounded for safety.

The measurement of the peak value of the voltage obtained by means of the divider may be conveniently and accurately made with a thyratron peak voltmeter.[5] However, the use of the voltage divider makes possible a determination of the wave-form of the roentgen tube voltage. Since valuable information may be obtained from a knowledge of this wave-form, the use of a cathode-ray oscillograph for measurement purposes is justified in view of the low cost and ease of operation of this device. The Duddell oscillograph used in obtaining the voltage and current wave-forms reproduced in the figures has the advantage of providing a permanent record, but it is expensive and its use requires the exposure and processing of an oscillographic film for each measurement. With a relatively inexpensive cathode-ray oscillograph the voltage wave-form may be observed on a fluorescent screen and if a permanent record is necessary this wave-form may easily be traced from the image on the screen.

The cathode-ray oscillograph tube best adapted for the purpose of roentgen tube peak voltage measurement and wave-form determination has a fluorescent screen with a phosphorescent lag, so that the image of voltage wave-form produced by a short exposure is retained for approximately thirty seconds after the exposure has ended. The oscillograph operates from a source of 110–120 volt alternating current and if used with a small voltage regulator may be accurately calibrated so that peak voltages may be obtained by measuring the height of the image on the screen. The input leads to the oscillograph are connected directly across the 100,000 ohm resistance of the voltage divider. This voltage divider can be constructed within an insulating framework approximately 2 feet square which can be suspended on the wires used to connect the divider to the overhead system. The cost and convenience of the combination of the high resistance voltage divider and the cathode-ray oscillograph are comparable with those of a good sphere-gap, and the information obtained is more complete and more accurate.

The purpose of the electrical calibration of roentgenographic apparatus is the predetermination of the roentgen tube voltage and current. These two factors are interdependent, and both calibrations must be performed simultaneously. Before beginning to calibrate, the machine should be turned on for several minutes and operated a few times in order that the various parts may reach approximately normal temperature. It is customary to choose the roentgen tube currents which are to be used routinely and calibrate the apparatus at each of these currents over the range of roentgen tube voltages desired. The exposure time used for calibration at any given current should be well below the maximum allowed by the tube rating for this current. If the allowable time is above 1.5 seconds, this time of exposure should be used and the current measured with the milliammeter, but if this is not permissible the impulse timer should be used to obtain an exposure time not greater than 1/10 second and the current measured with the ballistic milliampere-second meter. In the latter case, it is advisable to restrict the exposure time because the ballistic meter will produce less accurate deflections for longer exposure times.

In order to calibrate the apparatus at a given roentgen tube current, the cathode

current necessary to produce this chosen current at a medium voltage setting is determined. The roentgen tube voltage is then measured. If the voltage calibration method is of the third type described above the line voltage compensator is adjusted until the measured value of the voltage is equal to the voltage indicated by the voltage selecting switch dial. In this case the voltage calibration for this tube current is completed by recording the reading of the indicating voltmeter and determining the values of cathode current required to produce this tube current at other voltages. However, if one of the first two calibration methods is being used the measured value of the voltage and the reading of the pre-reading voltmeter or autotransformer tap number are recorded as one point of the calibration. The same procedure is repeated at other voltage settlings, each time recording cathode current, tube voltage and either voltmeter reading or tap number, depending upon the system in use. A curve or chart may then be prepared, from which may be determined the pre-reading voltmeter reading or autotransformer tap number required to produce the desired roentgen tube voltage at this chosen roentgen tube current. With any of the three methods of calibration it is necessary to keep a record of the cathode current for this roentgen tube current at various voltages.

Focal Spot-Film Distance. The factor of focal spot-film distance, while equally as important as those factors previously discussed, presents no complicated problems of specification and control. A good steel measuring rule or tape and care in measuring along a line perpendicular to the film from the film to the focal spot should insure accurate determination of this factor. It is convenient to place a mark on the outside of the roentgen tube to indicate the position of the focal spot within the tube. Any scales, mounted on the tube stand column or along the edge of the table, which have as an indicator a pointer attached to the arm or column of the tube stand should be carefully checked by direct measurement for each tube used on that stand.

It is sometimes necessary to calculate the effect of changing focal spot-film distance in conjunction with changes of other factors of technique. In making such calculations it must be noted that it is the intensity of radiation reaching the patient which largely determines the resultant roentgenographic densities, and not the intensity of radiation which would reach the film if the patient were not there. Consequently, calculations of focal spot-film distance in accordance with the inverse square law may lead to error. While no exact procedure has been developed, it is possible that the inverse square law may be applied with greater accuracy to the distance between the focal spot and some point (as yet undetermined) between the film and the part of the patient nearest the focal spot.

Roentgen Tube. Roentgenographic tubes of modern manufacture employ the line-focus principle to obtain the smallest possible effective focal spot with a given load rating. As the angle between the face of the anode and the central ray is decreased and the actual focal spot area is maintained constant, the size of the effective focal spot decreases with an accompanying decrease in geometric unsharpness. This method of reducing unsharpness is limited by the necessity for maintaining reasonably uniform intensity and sharpness over the entire film area. Line-focus tubes are usually constructed with an angle between the anode face and the central ray of 15° to 20°, although some tubes have been manufactured with an angle as small as 10°. Investigations of the variation of intensity[6] and geometric unsharpness[7] at various angles from the central ray have been made. It is recommended that 15° to 20° line-focus tubes be used at focal spot-film distances sufficiently great to keep the angle between the central ray and the ray to either edge of the film below 9°, while for a 10° line-focus tube this limiting angle should not exceed 6°.

The choice of a roentgenographic tube for a particular type of roentgenography is dependent upon the load which will be placed on the tube with the technique to be used. From the technical viewpoint it is most advantageous to obtain the smallest focal spot which will carry the required load with reasonable tube life. At the present time this condition is best satisfied by a rotating anode tube, although such a tube is expensive and economic considerations may prevent its use. However, regardless of whether a rotating anode tube or a stationary anode tube is used, it is important to note that various tube manufacturers employ different margins of safety in rating their tubes. The most conservatively rated tubes may be used routinely up to their maximum rating with good life, while those rated closest to the limit should be routinely operated at no more than 80 per cent of their maximum rating in order to insure long life.

It is advisable to make pinhole roentgenograms of the focal spot at regular intervals during the life of the roentgen tube. Some variation in size from the rated value may occur in manufacture and there may be further variations as the tube is used which can be detected in this way. The pinhole roentgenogram may also be used to determine the uniformity of radiation from the focal spot. Because of the helical form of the cathode coil, and the shape of the cathode shield, the electrons emitted are distributed so that there is greater intensity of radiation from the two longer sides of the rectangular focal spot than from the area in the center. The resulting non-uniformity of radiation in well designed tubes is not sufficient to be troublesome, but if this non-uniformity, or any which may develop from pitting of the focal spot, becomes excessive, it may cause important geometric unsharpness and distortion of very small images.

A pinehole roentgenogram may be obtained by exposing a film, without intensifying screens, to the radiation from the focal spot which passes through a small round hole in a sheet of lead placed between the tube and the film. For measurements of the focal spot of a roentgenographic tube the lead should be 1/16 inch thick. If the hole is approximately 0.3 mm. in diameter and the focal spot-pinhole distance (30 cm.) equals the pinhole-film distance (30 cm.), an exposure of 50 milliampere-seconds at 70 kv. (peak) will produce a satisfactory image on the film, under normal processing conditions, the dimensions of which image are equal to the effective focal spot dimensions plus the diameter of the pinhole, in this case 0.3 mm.[18] In order to observe clearly the uniformity of radiation from the focal spot, the focal spot-pinhole distance may be made half the pinhole-film distance with a resultant two to one enlargement of the image. It is extremely important in obtaining the image for measurement that the distances involved be carefully measured and that the pinhole and film be on a line with the central ray. It is convenient to mount the lead sheet and a holder for the film in a framework which may easily be positioned before the tube.

Intensifying Screens and Cassettes. An intensifying screen consists of a cardboard sheet uniformly coated with a fluorescent substance which emits actinic radiation when exposed to roentgen rays. The fluorescent substance is usually crystalline calcium tungstate, although zinc sulphide has been used. The use of intensifying screens reduces the exposure necessary to produce a roentgenogram of proper density and increases the contrast obtainable. The increased unsharpness produced by intensifying screen crystals must be compared with the reductions in the unsharpnesses due to motion and to the finite focal spot, which are made possible by the use of these screens.

The intensification factor, or speed, of a pair of intensifying screens is defined as the ratio of the exposure required to produce a given density on the film without screens to the exposure necessary with screens, under specified conditions of

density, filtration, quality of radiation, etc.[8] Even when measured under carefully controlled conditions, the intensification factor will be valid only for film having the same relative response to roentgen radiation and actinic radiation as the film used to determine this factor. Since it is impossible to establish a practical standard method of measurement, the characteristics of intensifying screens cannot be specified quantitatively in a simple manner, and the choice of screens must depend upon comparative tests of the various types available. Speed comparisons may be made conveniently and accurately by obtaining roentgenograms of an aluminum ladder with the various screens to be compared. The films used should be from the same box and all developed together, and the exposures should be chosen to produce an average density of approximately 1.0. If a range of exposure times is used with each screen, keeping all other technique factors the same, it is then possible to determine the relative exposure times necessary to obtain similar roentgenograms with the various screens. Comparisons of unsharpness produced by various screens may be obtained by making roentgenograms of a wire mesh in contact with the front of each cassette in which screens to be compared are mounted. If the exposures are chosen to produce equal densities of approximately 1.0 in the spaces between the wire images on all such roentgenograms, the clearness of the images of the wires will serve as a comparison of the unsharpness.

While the ideal intensifying screen would be one having both high speed and negligible unsharpness, the characteristics of the known fluorescent substances preclude the possibility of producing such a screen. It is necessary to effect a compromise between speed and sharpness such that the combination of the chosen screen and the type of focal spot used will produce the least unsharpness. Tests made with both stationary anode and rotating anode tubes indicate clearly that screens with very high intensification factors, and consequently great unsharpness, should not be used unless the capacity of the high-tension generating equipment is so limited as to require the aid of high speed screens. This makes inadvisable the use of zinc sulphide screens (which also have the disadvantage of producing mottling at higher voltages) and very high speed calcium tungstate screens. These tests also indicated that medium speed screens should be used with stationary anode tubes while best results with rotating anode tubes were obtained with low speed screens having the least obtainable unsharpness. Regardless of the type of screen chosen, it is important for routine work that all screens of the same type used in the laboratory have the same intensification factor within ± 5 per cent of the average. It is recommended that all screens be replaced at the same time so that the manufacturer may be required to supply properly matched pairs. The uniformity of speed among the various screens of a given type may be determined from aluminum ladder roentgenograms in the manner described above.

The cassette in which the intensifying screens are mounted should be light-tight, and the front of the cassette should be of such material and of such thickness that it is mechanically strong without producing excessive absorption of roentgen radiation. The lid of the cassette should be incapable of any sliding motion which may result in scratching the screens and when the cassette is closed it should produce everywhere intimate contact between the film and the screens. It is extremely important that good contact be produced and every cassette should be tested by roentgenographing a wire mesh covering the entire cassette and in contact with the front of the cassette. The exposure should be chosen to obtain a density of approximately 1.0 in the spaces between images of the wires. Any area of poor contact will be indicated by the excessive unsharpness of the image of the wire mesh in contrast with the sharp image under those areas having good contact. Cassettes which do not pro-

duce uniformly good contact should be reconditioned by the manufacturer, or replaced. New screens should be mounted in accordance with the instructions of the manufacturer and only in cassettes which have been carefully inspected and tested.

The life of an intensifying screen is largely determined by the care given it. As an economic measure and to insure against faulty roentgenograms it is important to handle the cassettes with care in the dark room and to inspect and clean the screens regularly. Precautions should be taken to prevent the scratching of screens while loading and unloading film, and the danger of splashing drops of water or processing chemicals on the screens should be scrupulously avoided. The screens should be inspected regularly in natural light, and whenever necessary, cleaned by the method recommended by the manufacturer.

Roentgen Films, Processing Materials and Procedure. The important criteria in the choice of a make of film and developer and methods for determining these criteria have been discussed.[9] These criteria are the speed characteristics, contrast characteristics and the constancy of these characteristics. It is desirable to use films and developing solutions with high speed and contrast, and it is important that these characteristics remain as constant as possible. Some variation in the characteristics of films and developers will occur in manufacture and still further variations result from the conditions of transportation and storage. Lack of constancy of the first type is beyond the control of the roentgenologist and he must depend upon the manufacturer's efforts to maintain the constancy of his products. Variations of the second type may be minimized by carefully planning the purchase of films and developer powders. Films particularly should be bought frequently and in small quantities, and an attempt should be made always to have the dealer supply films of approximately the same age which have been subject to approximately the same conditions of transportation and storage. If the dealer has a large volume of film business and receives regular shipments from the manufacturer, such an arrangement can be effected without difficulty and will result in appreciable reduction of variations in speed and contrast. Tests may be performed at regular intervals to check the magnitude of any variations.[9]

The processing methods used in the dark room should be carefully standardized. In particular, this requires accurate control of developing time and developing solution temperature and an accurate determination of the potency of the developer. In order to eliminate appreciable variations in the density of the processed roentgenograms, it is necessary to maintain the temperature of the developer constant to ± 0.5°F. This requires a thermostatically controlled mixing valve and an ample supply of hot and cold water. If there is not sufficient cold water available during the summer months a refrigerator is necessary, and under any circumstances considerations of efficiency suggest the use of a pre-cooler for the cold water supply. The time of development must be constant to ± 10 seconds, which requires an accurate dark room timer and careful attention to the removal of films from the developer immediately after the proper time interval has elapsed. The films should be removed quickly without allowing developer to drip back, since the oxidized developer which drips back materially reduces the useful life of the solution. To replace developer which is carried away by the films fresh developer in sufficient quantity to maintain proper level in the tank should be added and carefully stirred in after processing each group of ten 14 by 17 in. films or their equivalent.

The maintenance of standard development as the solution ages requires regular increases in the developing time and in order to do this accurately the developer must be calibrated. The method of calibration[10,15] is as follows:

1. An eight-step aluminum ladder 14 in. long with $\frac{1}{2}$ in. wide steps varying in thickness

by $\frac{1}{8}$ in., from $\frac{1}{8}$ to 1 in. is used to prepare the test film ($8\frac{1}{2}$ by 14 in.). A roentgenogram of the ladder is made with intensifying screens at the following technique: roentgen tube voltage 75 kv. (peak); roentgen tube current 100 ma.; exposure time 1/10 sec.; focal spot-film distance 6 ft. After exposure a strip 2 in. in width is cut from each end of the film and discarded. The remaining portion of the film is cut into twenty strips, each $\frac{1}{2}$ in. in width. These strips are kept in a light-tight box.

2. After fresh developer has been made one strip is developed at the standard time and temperature. This strip, after fixing and drying, becomes the standard. After development of about twenty-five 14 by 17 in. films, or their equivalent, per 5 gallons of developer, three strips are developed: one for the developing time then being used, one for a time $\frac{1}{4}$ minute greater, and the other for a time $\frac{1}{2}$ minute greater. After these strips have been fixed, washed and dried they are compared with the standard. The developing time used for the strip most nearly identical with the standard is used for the next group of twenty-five films. By repeating this procedure regularly the developing time can be increased by the correct amount to maintain constant development until the developer is exhausted, which condition is indicated by the impossibility of obtaining a strip equivalent to the standard. There should be available a sufficient number of strips after the developer is exhausted to check the new developing solution.

3. When fresh developer is made three strips are developed with standard developing time, $\frac{1}{4}$ minute less than standard and $\frac{1}{4}$ minute greater than standard time. If the strip developed for the standard time is not identical with the standard strip developed with the previous solution, the characteristics of the new developer are different and require a different developing time. The developing time to be used with this solution should be that for which the strip most comparable with the standard was developed. Another set of test strips is prepared and a standard strip obtained by developing at the time chosen for the fresh solution. In this way it is possible not only to obtain uniform development during the life of one developer, but to compensate for variations in new solutions.

Specification of Technique. It is clear from the above discussions and other analyses[19] of the individual factors which influence the final roentgenogram that the general specification of technique requires more than the assignment of a value to each of these variables. The methods of control and calibration which have been described will permit the roentgenologist to establish optimum techniques for his own laboratory and to reproduce these techniques at will. However, there are so many variations in characteristics of different types of equipment which are difficult to determine that the precise specification of these techniques for use in other laboratories is impossible by the method of designating the separate factors. If the apparatus is accurately calibrated in accordance with the recommended methods, such designation will give a fair approximation, and it is a necessary first step. The additional precision must be the result of a method of specification which takes cognizance of the products of all the factors in combination. These products are the density, contrast and unsharpness of the resultant roentgenogram.

The method of specification which best combines accuracy and simplicity makes use of an aluminum ladder. If a roentgenogram of such a ladder is made, and the density under each step is measured,* a curve may be drawn of density vs. thickness of aluminum. The shape and position of this curve depend on all the technique factors and if any single factor is varied the curve will vary.[16] However, it is possible to change several factors simultaneously, for example, exposure time and focal spot-film distance, without altering the curve. Therefore, such a curve defines a set of roentgenographic techniques which will produce the same density and contrast. If a roentgenogram of the aluminum ladder is made with a technique developed in one

* If a densitometer is not available, this measurement may be made with good approximation by visual comparison with a standard strip of measured densities which may be obtained from one of the manufacturers of roentgen film. It is extremely important in making such a visual comparison that the standard step and the unknown step be placed side by side with edges touching and that the light from every portion of the face of the viewing box other than that illuminating the two steps be blocked off.

laboratory, the density vs. thickness of aluminum curve will provide any other laboratory with sufficient data so that they can determine a technique from trial aluminum ladder roentgenograms which will produce the same density and contrast as the original. However, this in itself is not sufficient, since there is no guarantee that the unsharpness produced by the two techniques will be the same.

The unsharpness of a roentgenogram depends upon the type of intensifying screens, the time of exposure, the size of the roentgen-tube focal spot and the focal spot-film distance. Since the unsharpness is not so critical a function of these variables as the density and contrast, a careful specification will fix them with sufficient accuracy. With these factors determined the use of the aluminum ladder as described above will insure the complete reproducibility of roentgenographic results.

The general specification of any given technique includes:

1. Careful specification of each of the technical factors.
2. The density vs. thickness of aluminum curve for an aluminum ladder roentgenogram made with this technique.

Any laboratory desiring to reproduce this technique may adjust the individual technical factors in accordance with the specifications and make a roentgenogram of an aluminum ladder. If the resultant density vs. thickness of aluminum curve differs from the original, one or more of the technical factors, other than those which influence unsharpness, may be changed in such a manner as to produce a curve equivalent to the original. When this has been done the resultant roentgenograms have the same density, contrast and unsharpness as those taken in the laboratory in which the technique was developed.

CONCLUSIONS

The problem of standardizing roentgenographic technique involves the accurate specification and reproduction of technique. These requirements are fulfilled by:

1. Precise control of apparatus and procedure.
2. Accurate calibration of technical factors.
3. Use of an aluminum ladder to obtain exact reproducibility of density and contrast.

Methods for satisfying these requirements have been presented.

On the basis of these methods some preliminary work has been done in the field of chest roentgenography.[17] If adequate standardization is to be achieved, it is necessary that this work be greatly extended. It is our hope that the methods described in this paper will be of use to roentgenologists in collecting the data upon which standardization must be based.

REFERENCES

1. Weyl, C., Warren, S. R., Jr., and O'Neill, D. B. Survey of chest roentgenographic technique. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 526–533.
2. Weyl, C., Warren, S. R., Jr., and O'Neill, D. B. Choice of certain technical factors for chest roentgenography. Am. J. Roentgenol. & Rad. Therapy, 1936, *35*, 534–539.
3. Weyl, C., Warren, S. R., Jr. and McPhedran, F. M. Methods of measuring and recording roentgen-ray tube currents and voltages. Am. J. Roentgenol. & Rad. Therapy, 1931, *26*, 871–877.
4. Weyl, C., Warren, S. R., Jr., and Garrahan, C. J. Comparative tests on single valve rectified and mechanically rectified radiographic apparatus. *Radiology*, 1932, *19*, 105–109.
5. Weyl, C., Warren, S. R., Jr., and Garrahan, C. J. A thyratron peak voltmeter. Am. J. Roentgenol. & Rad. Therapy, 1932, *28*, 544–546.
6. Zintheo, C. J., Jr. Variations in intensity and quality of roentgen-ray output as affected by angle to the central ray, the roentgen tube and the roentgen machine. Am. J. Roentgenol. & Rad. Therapy, 1937, *37*, 98–104.
7. Andrus, P. M., and Hambleton, A. Capacity of x-ray tubes as influenced by geometric design of focal spot, including advantages and limitations of line focus principle. *Radiology*, 1932, *18*, 521–531.
8. Swindells, F. E. Effect of technic on the speed of intensifying screens. *Radiology*, 1930, *14*, 387–390.

9. WEYL, C., WARREN, S. R., JR., and O'NEILL, D. B. An investigation of x-ray films and developing solutions. *Radiology*, 1937, *29*, 64–78.
10. CHAMBERLAIN, W. E., and NEWELL, R. R. Development of roentgen films; method of determining potency of the developer, AM. J. ROENTGENOL. & RAD. THERAPY, 1930, *23*, 549–552.
11. WEYL, C., and WARREN, S. R., JR. Apparatus and Technique for Roentgenography of the Chest. Charles C. Thomas, Springfield, Ill., 1935, p. 45.
12. *Ibid.*, p. 30.
13. *Ibid.*, p. 34.
14. *Ibid.*, p. 38.
15. *Ibid.*, p. 136.
16. *Ibid.*, p. 131.
17. *Ibid.*, p. 93.
18. BRONKHORST, W. Kontrast und Schärfe im Röntgenbilde, Georg Thieme, Leipzig, 1927, p. 84.
19. ZINTHEO, C. J., JR. Specification of roentgenographic technique. AM. J. ROENTGENOL. & RAD. THERAPY, 1937, *38*, 352–362.

Vol. 40, No. 5

THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

Editor: Lawrence Reynolds, M.D. *Assistant Editor:* Ruth Bigelow, B.S.

Editorial Board: A. C. Christie, M.D. E. H. Skinner, M.D. Lauriston S. Taylor
Advisory Board for Pathology: James Ewing, M.D. Eugene L. Opie, M.D.
Collaborating Editors: The Officers and Committee Members of the Societies of which this Journal is the official organ, whose names appear on this page, are considered collaborating editors of this Journal.
Foreign Collaborators: A. Béclère, M.D., Paris, Gösta Forssell, M.D., Stockholm, G. F. Haenisch, M.D., Hamburg, R. Ledoux-Lebard, M.D., Paris.

Publisher: Charles C Thomas, 220 East Monroe St., Springfield, Illinois.

Issued Monthly. Subscription $10.00 per year, $11.00 in Canada and $12.00 in foreign countries. Advertising rates submitted on application: Editorial office, 110 Professional Building, Detroit, Mich. Office of publication 220 E. Monroe St., Springfield, Ill. Information of interest to all readers will be found on page iv.

Officers and Standing Committees

THE AMERICAN ROENTGEN RAY SOCIETY

President: J. W. Pierson, Baltimore, Md.; *President-Elect:* E. L. Jenkinson, Chicago, Ill.; *1st Vice-President:* W. McD. Doughty, Cincinnati, Ohio; *2d Vice-President:* C. G. Dyke, New York City; *Secretary:* C. B. Peirce, Royal Victoria Hospital, Montreal, P.Q., Canada; *Treasurer:* J. B. Edwards, 144 Woodridge Place, Leonia, N. J.; *Historian:* Percy Brown, 475 Commonwealth Ave., Boston, Mass.

Executive Council: J. W. Pierson, E. L. Jenkinson, W. McD. Doughty, C. G. Dyke, C. B. Peirce, J. B. Edwards, Lawrence Reynolds, H. D. Kerr, E. E. Downs, M. C. Sosman, C. A. Waters, B. R. Kirklin, R. C. Beeler, R. S. Bromer, U. V. Portmann, Chairman, Cleveland Clinic, Cleveland, Ohio.

Committee on Hospital Relations: F. F. Borzell, Philadelphia, Pa., D. S. Childs, Syracuse, N. Y., D. L. Palmer, Portland, Ore., W. H. Stewart, Chairman, New York City.

Committee on Safety and Standards: E. C. Ernst, St. Louis, Mo., R. R. Newell, San Francisco, Calif., Douglas Quick, New York City, K. W. Stenstrom, Minneapolis, Minn., Lauriston S. Taylor, Chairman, Washington, D. C.

Publication Committee: E. P. Pendergrass, Philadelphia, Pa., M. C. Sosman, Boston, Mass., H. E. Ruggles, Chairman, San Francisco, Calif.

Finance Committee: H. J. Walton, Baltimore, Md., Robert Drane, Savannah, Ga., H. D. Kerr, Chairman, Iowa City, Ia.

Committee on Scientific Exhibits: V. W. Archer, University, Va., S. W. Donaldson, Ann Arbor, Mich., E. E. Downs, Chairman, 509 N. Broad St., Woodbury, N. J.

Representatives on the American Board of Radiology: B. R. Kirklin, Rochester, Minn., Leopold Jaches, New York City, LeRoy Sante, St. Louis, Mo.

Member, National Research Council: Henry J. Walton, Baltimore, Md.

Editor: Lawrence Reynolds, 110 Professional Building, Detroit, Mich.

Assistant Editor: Ruth Bigelow, 110 Professional Building, Detroit, Mich.

Editorial Board: A. C. Christie, E. H. Skinner, Lauriston S. Taylor.

Advisory Board for Pathology: James Ewing, Eugene L. Opie.

Fortieth Annual Meeting: Chicago, Ill., Sept. 19–22, 1939.

THE AMERICAN RADIUM SOCIETY

President: William P. Healy, New York City; *President-Elect:* Lawrence A. Pomeroy, Cleveland, Ohio; *1st Vice-President:* W. E. Costolow, Los Angeles, Calif.; *2nd Vice-President:* H. E. Martin, New York City; *Secretary:* F. W. O'Brien, 465 Beacon St., Boston, Mass.; *Treasurer:* Charles L. Martin, Baylor Hospital, Dallas, Texas.

Executive Committee: G. W. Grier, Chairman, Pittsburgh, Pa., Zoe A. Johnston, Pittsburgh, Pa., E. H. Skinner, Kansas City, Mo.

Program Committee: L. A. Pomeroy, Chairman, Cleveland, Ohio, E. T. Leddy, Rochester, Minn., G. E. Binkley, New York City.

Publication Committee: E. H. Skinner, Chairman, Kansas City, Mo., W. E. Howes, Brooklyn, N. Y., H. N. Cole, Cleveland, Ohio.

Research and Standardization Committee: Wilhelm Stenstrom, Chairman, Minneapolis, Minn., E. P. Pendergrass, Philadelphia, Pa., Edith H. Quimby, New York City.

Education and Publicity Committee: Fred J. Taussig, Chairman, St. Louis, Mo., H. B. Hunt, Omaha, Neb., H. H. Ashbury, Memphis, Tenn.

Advisory Committee on Roentgen-ray and Radium Protection: W. E. Chamberlain, Chairman, Philadelphia, Pa., G. C. Wilkins, Manchester, N. H., L. A. Campbell, Saginaw, Mich.

Janeway Lecture Committee: Curtis F. Burnam, Chairman, Baltimore, Md.

Committee on Arrangements: Edwin C. Ernst, Chairman, St. Louis, Mo., L. R. Sante, St. Louis, Mo., A. N. Arneson, St. Louis, Mo.

Representatives on The American Board of Radiology: Henry Schmitz, Chicago, Ill., Rollin H. Stevens, Detroit, Mich., B. P. Widmann, Philadelphia, Pa.

Twenty-fourth Annual Meeting: St. Louis, Mo., 1939.

EDITORIALS

THE ANNUAL MEETING

THE Thirty-ninth Annual Meeting of the American Roentgen Ray Society was held at Haddon Hall, Atlantic City, on September 20 to 23, 1938. As was anticipated, the quality and type of program which had been arranged by the President-Elect, Dr. John W. Pierson, and his program committee attracted an unusual number of members of the Society and guests, over 500 being registered. Following the installation of the President, the first scientific session was given over to the delivery of the President's address and a group of interesting papers having to do with roentgen and radium therapy of various diseases. In the afternoon session the papers dealt with the physiology and pathology of the gastrointestinal tract. On Tuesday evening the Caldwell Lecture was given by Dr. Joseph McFarland, Emeritus Professor of Pathology, University of Pennsylvania, his subject being "Keeping in Touch with Science." It was a very scholarly and intriguing sort of discussion having to do, in part, with accepted terminology in scientific literature. Dr. McFarland suggested, among other things, that the word "survival," which curiously enough had been used by one of the first speakers on the program, Dr. Leucutia, should be used instead of the word "cure" in referring to the results of treatment of carcinoma after five, ten and fifteen year periods. Following the completion of the lecture, Dr. McFarland was presented with the Caldwell Medal by Dr. Pierson.

The papers on the scientific program on Wednesday morning were on paradoxical movement of the diaphragm and mediastinal shift, cinefluorographic studies; correlation of post-mortem chest teleroentgenograms with autopsy findings; roentgen visualization of the soft tissues in pregnancy; internal dimensions of the female pelvis, and the anatomic and roentgenologic considerations of anterior and posterior notching of the vertebral bodies as seen in the newborn. On Wednesday afternoon one of the most important and instructive symposiums of the entire meeting was given; the symposium was on heart disease and was arranged by Dr. M. C. Sosman. These very instructive papers dealt with the normal anatomy and estimation of heart size; the clinical value of visualization of the heart chambers, the pulmonary circulation and the great blood vessels in man. This latter was one of the outstanding papers and its importance could hardly be overestimated. The study as presented by Dr. George P. Robb and Dr. Israel Steinberg, opens up an entirely new field in the study of cardiovascular diseases and those who were privileged to sit in the audience and listen to this paper will recall it as epoch-making. It offered not only a technique of diagnostic significance but a new approach to the study of the dynamic anatomy and physiology of the heart, the pulmonary circulation and the great vessels in both normal and pathological conditions. From the initial report of this technique one may look forward to extraordinary advances in the diagnosis of cardiovascular diseases by roentgenologic methods. Following this, the other papers in the symposium were on pericarditis; acquired valvular heart disease; non-valvular heart disease; congenital heart disease; and aorta and great vessels. The discussion on this instructive symposium was given by Dr. Samuel Levine and Dr. George W. Holmes.

On Thursday the fifth scientific session comprised a group of papers dealing with treatment, and included the present status

of roentgen treatment of sinus infections; the combined roentgen and radium treatment of carcinoma of the cervix; carcinoma of the anus, its incidence, pathology and radiation treatment; skin reactions with 400 kv. and 200 kv. unfiltered radiation, and roentgen-ray diffraction studies of human nervous tissue.

The sixth scientific session consisted of a symposium on growth, arranged by Dr. E. P. Pendergrass. This unusual and interesting program dealt with the chemical structure and its relation to growth and development; growth hormones in plants; radiation, mutation and the gene; viruses and abnormal growths; and biology of the cancer cell.

On Friday morning the papers were on mediastinal primary tuberculous lymphoma in the adult, resembling Hodgkin's disease; liposarcoma of the lung and mediastinum; tuberculous tracheobronchitis; roentgen localization of acute lung abscess; methods for determining pineal position with analysis of their errors; roentgen findings in renal tuberculosis, and lateral pyelography.

The concluding scientific session on Friday afternoon was composed of papers on intracranial complications attending roentgen therapy for carcinoma of the scalp; use of concrete protection for roentgen voltages up to 400 kv.; radium quantity meter; relief of pain; aspiration biopsy of tumors in inaccessible organs under roentgenoscopic guidance; a method for obtaining greater ratio of deep to surface dosage, and roentgen treatment of primary inoperable carcinoma of the breast by the method of multiple converging beams.

The fine quality of the papers and the stimulus to the participants in the program by the large attendance at all of the sessions stamped this as an excellent meeting.

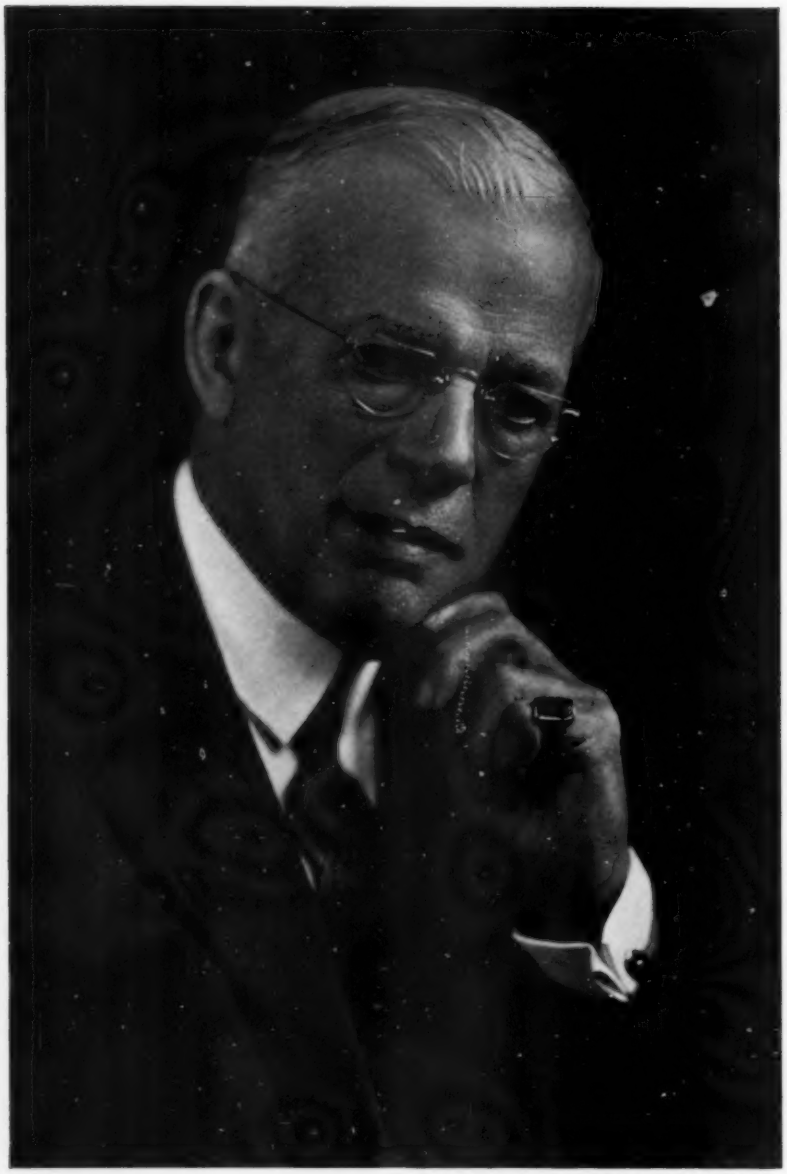
In addition to the regular program, there was arranged a group of educational courses which occupied the hour from eight to nine preceding the beginning of the morning's scientific sessions. These courses proved to be one of the most instructive and valuable parts of the program and, following this precedent, those having to do with future arrangements should plan to make them a regular part of the program.

The scientific exhibit committee under the chairmanship of Dr. Vincent W. Archer had arranged a comprehensive exhibit dealing with timely subjects, and the admirable grouping of the various exhibits in an anatomical and pathological order facilitated their study. Following a precedent established at one of the recent meetings, a period was set aside following the morning sessions to permit a study of the scientific exhibits. This is a custom which should continue to be followed because the committee and the exhibitors devote a great deal of time and effort to this particular feature and too frequently in the past insufficient time has been available for viewing the exhibits.

The social events of the meeting such as the golf tournament on Monday and the annual banquet on Thursday evening added to the enjoyment of the occasion.

Not the least in the order of importance were the commercial exhibits. The manufacturers had assembled a fine and most comprehensive exhibit, and the Society, through its Journal, desires to express to the various exhibitors its deep appreciation for the quality and extent of the exhibits.

Such a scientific program and the extent and scope of the scientific and commercial exhibits, together with the physical arrangements of Haddon Hall and the courtesy and efficiency of its staff, make the Atlantic City meeting one of the most memorable in the Society's history.



Photograph by Bachrach

HARVEY WARD VAN ALLEN
1869–1938

THE death of Dr. Harvey Van Allen removes another eminent name from the rapidly diminishing list of American pioneers in radiology and adds a worthy record to the steadily expanding history of scientific progress.

In the cherished possession of certain older American radiologists is a faded photograph which depicts a little company of men and women, most of them young and in summer attire, seated beneath the trees on a bank of the upper Niagara River. This group, scarcely over threescore in number, represents the American Roentgen Ray Society and its friends, assembled during late August of 1906 in annual meet-

ing for the seventh time since its organization.

The previous year had marked the election of three new members—James Wilson Hunter, Sidney Lange and Harvey Ward Van Allen, who represented, respectively, the Colonial South, the great Ohio Valley and ancient New England, thus augmenting the comprehensive character of the Society membership that had obtained since the formation of its Charter group. The figures of these three are to be descried in the photograph, albeit with the aid of a glass, perhaps, by their living contemporaries. That of Doctor Van Allen is at the observer's left, his features almost in profile and indeed but little more youthful in contour than they have since appeared to his colleagues as year after year has passed. The younger of us, who may have known him less intimately, might nevertheless recognize at once, from this old record, a figure we have seen at nearly every meeting of the Society. To the older of us, greeting him for the last time, as it transpires, at the International Congress, he appeared even as always—sedate of manner, sound of opinion and firm of conviction. By virtue of his faithful annual attendance as a Member down the years from that early assembly at Niagara Falls, of his wise counsel as an Officer in matters of policy and management and of the weight of his spoken word in open meeting, Harvey Van Allen had become one of the mainstays of the American Roentgen Ray Society, his stability proven by the crucial tests of the pioneer years.

Doctor Van Allen was the only child of the Reverend Chauncy Elliot and Phoebe (Ward) Van Allen. He was born in Jersey City, New Jersey, on the fourteenth of June, 1869. His father, a Baptist clergyman and editor, removed his family soon after his son's birth to Watkins Glen, New York. The lad received his earlier education at Cook Academy in the neighboring community of Montour Falls, and from this school he entered Cornell University, where he was graduated with the class of 1888. Three years later he received his medical degree from Albany Medical College, thereafter serving at the Springfield (Massachusetts) Hospital as the first house physician to be graduated there.

Van Allen remained in Springfield, establishing his office in Maple Street, where he practised privately for forty-six years to the time of his death. Aside from his extensive private work he was active in his widespread hospital connections. His allegiance to the Springfield Hospital was constant from the period of his internship. In addition he became not only a consultant on the Staffs of the Springfield and the Wesson Hospitals, but, as well, a Staff member of the Cooley-Dickinson Hospital at Northampton and the Mary Lane Hostal at Ware, Massachusetts.

Harvey Van Allen was one of the New England pioneers in radiology. With this specialty he identified himself during the early years of this century and his every effort since then had been exerted toward its furtherance, both within and beyond his own community. As Councillor, for his district, of the Massachusetts Medical Society, his energy had been instrumental in the formation of its Section of Radiology and Physiotherapy. He was elected a Member of the American Roentgen Ray Society in 1905 and had served faithfully as its Vice-President in 1909, in 1912 and in 1918. He was elected to the Radiological Society of North America in 1920. In the American College of Radiology, of which he was one of the original group of Fellows of 1923, Doctor Van Allen was notably active. He became a member of its Board of Chancellors in 1928 and so remained until the event of his election to its Presidency during the course of his last illness—ten years of loyal devotion to an association he helped to build upon a foundation of the idealism that was a part of the fabric of his own philosophy of life.

Having deep faith in the quality of the strength engendered by union, Van Allen firmly believed in the salutary advantages of well-founded medical organization, pri-

marily to the practitioner and ultimately to the patient. This fact is attested not alone by his close participation in the work of the major American radiological societies but by his early affiliation, as member and officer, with his national and state medical societies—a stepping-stone to his subsequent loyal support of smaller groups of both general and special function. These organizations absorbed the benefit of the wisdom of his long experience, and his counsel was never sought in vain. He was an able coadjutor in the constructive purposes of the Springfield Medical Society and the Springfield Academy of Medicine, as well as in the formation of the New England Roentgen Ray Society.

While Doctor Van Allen was not a voluminous contributor to the literature of radiology, his occasional writings were important by reason of their timeliness and the high repute of his opinion. Indeed, one of his earliest papers (1905) dealt with a matter of the greatest moment at that day —the danger to the operator of the *x-ray atmosphere*. The validity of Leonard's theory that it is the static field, and not the roentgen-rays *per se*, which produces the deleterious skin effect had been disproven eight years before, but Van Allen was firmly insistent that the uncontrolled *secondary* emanations are not to be disregarded. The march of Time has shown the wisdom of his warning.

As additions to the literature of therapy, Van Allen wrote on lupus vulgaris (1907), tonsillitis and hyperthyroidism. In 1923, he reviewed the status of radiotherapy as it existed at that moment. In roentgen diagnosis, his writings covered divers pathological entities, especially those of the respiratory and alimentary tracts and of the ductless glands. Instrumental devices for the enhancement of diagnostic efficiency fascinated him and stimulated his pen. In 1916 he described a roentgen pelvimetric method that was indeed "easy and accurate," as he described it. He was an enthusiast over the principle of the Potter-Bucky diaphragm; he accurately foretold (1921) its wide application and lent his supervision and encouragement to the production of the smoothly running Violi travelling-grid apparatus, in connection with which he mentions the tentative use of the curved cassette.

Harvey Van Allen's sense of civic responsibility and his religious convictions were equally deep. His interest, his participation even, in governmental affairs of his community were, in degree, greater than in the case of most medical men and were curtailed only by the demands of his profession. He was a prominent figure in the Baptist Church, according it generous support both during his life and by endowment.

This gentleman of calm demeanor, whose well-considered words were evenly uttered and whose thoughts were deep, but whose habitually tranquil countenance could lighten quickly with satisfaction and pleasure, took comfort and quiet joy in his contacts with his fellows. He was a wholly unselfish man. All who constituted these contacts in the daily course of his professional life, whether patients or associates, received the same measure of generous and conscientious consideration as did the moral obligations of his church or his fireside.

These qualities of heart and mind made of Harvey Van Allen a welcome colleague, a wise physician and a steadfast friend. As such was he known and as such will he be remembered.

Percy Brown

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this section solicited promptly after the events to which they refer.

MEETINGS OF ROENTGEN SOCIETIES*

UNITED STATES OF AMERICA

AMERICAN ROENTGEN RAY SOCIETY
Secretary, Dr. C. B. Peirce, Royal Victoria Hospital, Montreal, Canada. Annual Meeting: Chicago, Ill., Sept. 19–22, 1939.

AMERICAN COLLEGE OF RADIOLOGY
Secretary, Dr. E. L. Jenkinson, 1439 S. Michigan Ave., Chicago, Ill. Annual meeting, 1939: To be announced.

SECTION ON RADIOLOGY, AMERICAN MEDICAL ASSOCIATION
Secretary, Dr. J. T. Murphy, 421 Michigan St., Toledo, Ohio. Annual meeting: St. Louis, Mo., May 15–19, 1939.

RADIOLOGICAL SOCIETY OF NORTH AMERICA
Secretary, Dr. D. S. Childs, 607 Medical Arts Bldg., Syracuse, N. Y. Annual meeting: Pittsburgh, Pa., Nov. 27–Dec. 2, 1938.

RADIOLOGICAL SECTION, BALTIMORE CITY MEDICAL SOCIETY
Secretary, Dr. Walter L. Kilby, Baltimore. Meets third Tuesday each month, September to May.

RADIOLOGICAL SECTION, CONNECTICUT MEDICAL SOCIETY
Secretary, Dr. Max Climan, 242 Trumbull St., Hartford, Conn. Meets twice annually in May and September. Special meetings may be called by the Chairman.

RADIOLOGICAL SECTION, LOS ANGELES CO. MED. SOC.
Secretary, Dr. M. L. Pindell, 678 S. Ferris Ave., Los Angeles, Calif. Meets on second Wednesday of each month at County Society Building.

RADIOLOGICAL SECTION, SOUTHERN MEDICAL ASSOCIATION
Secretary, Dr. Roy G. Giles, Temple, Texas.

BROOKLYN ROENTGEN RAY SOCIETY
Secretary, Dr. E. Mendelson, 120 E. 19th St., Brooklyn, N. Y. Meets monthly on first Tuesday, October to April.

BUFFALO RADIOLOGICAL SOCIETY
Secretary-Treasurer, Dr. Joseph S. Gian-Franceschi, 610 Niagara St., Buffalo, N. Y. Meets second Monday of each month except during summer months, place of meeting selected by the host.

CHICAGO ROENTGEN SOCIETY
Secretary, Dr. R. G. Willy, 1138 N. Leavitt. Meets second Thursday of each month October to May inclusive at the Palmer House.

CINCINNATI RADIOLOGICAL SOCIETY
Secretary, Dr. J. E. McCarthy, 707 Race St., Cincinnati, Ohio. Meets third Tuesday of each month, October to May, inclusive.

CLEVELAND RADIOLOGICAL SOCIETY
Secretary, Dr. Harry Hauser, 3395 Scranton Rd. Meetings are held at 6:30 P.M. at the Mid-Day Club rooms on the fourth Monday of each month from October to April, inclusive.

DENVER RADIOLOGICAL CLUB
Secretary, Dr. E. A. Schmidt, 4200 E. 9th Ave., Denver, Colo. Meets third Tuesday of each month.

DETROIT ROENTGEN RAY AND RADIUM SOCIETY
Secretary, Dr. E. R. Witwer, Harper Hospital. Meets monthly on first Thursday from October to May, at Wayne County Medical Society Building.

FLORIDA STATE RADIOLOGICAL SOCIETY
Secretary, Dr. J. H. Lucinian, 403 Huntington Bldg., Miami, Florida. Meetings held twice a year, May and November.

GEORGIA RADIOLOGICAL SOCIETY
Secretary, Dr. R. C. Pendergrass, Prather Clinic Bldg., Americus, Ga. Meets twice annually: in November and at annual meeting of Medical Association of Georgia in the spring.

ILLINOIS RADIOLOGICAL SOCIETY
Secretary, Dr. E. P. Halley, Decatur and Macon County Hospital, Decatur, Ill. Meetings held quarterly, time and place designated by president.

INDIANA ROENTGEN SOCIETY
Secretary, Dr. C. C. Taylor, 23 E. Ohio St., Indianapolis, Ind. Meeting held the second Sunday in May annually.

LONG ISLAND RADIOLOGICAL SOCIETY
Secretary, Dr. Marcus Wiener, 1430-48th St., Brooklyn, N. Y. Meets at Kings County Med. Soc. Bldg. on fourth Thursday, each month, October to May, 8:30 P.M.

MICHIGAN ASSOCIATION OF ROENTGENOLOGISTS
Secretary, Dr. C. S. Davenport, St. Lawrence Hospital, Lansing. Three meetings a year, Fall, Winter, Spring.

MILWAUKEE ROENTGEN RAY SOCIETY
Secretary, Dr. S. A. Morton, Columbia Hospital, Milwaukee, Wis. Meets monthly. Place of meeting named by the president.

MINNESOTA RADIOLOGICAL SOCIETY
Secretary, Dr. H. M. Weber, Mayo Clinic, Rochester, Minn.

NEBRASKA RADIOLOGICAL SOCIETY
Secretary, Dr. D. A. Dowell, Medical Arts Bldg., Omaha, Nebr. Meets first Wednesday of each month, at 6 P.M., at either Omaha or Lincoln.

NEW ENGLAND ROENTGEN RAY SOCIETY
Secretary, Dr. A. O. Hampton, Massachusetts General Hospital, Boston, Mass. Meets monthly on third Friday, Boston Medical Library.

RADIOLOGICAL SOCIETY OF NEW JERSEY
Secretary, Dr. W. J. Marquis, 198 Clinton Ave, Newark, N. J. Meets annually at time and place of State Medical Society. Mid-year meetings at place designated by the president.

NEW YORK ROENTGEN SOCIETY
Secretary, Dr. R. D. Duckworth, 170 Maple Ave., White Plains, N. Y. Meets monthly on third Monday, New York Academy of Medicine, at 8:00 P.M.

NORTH CAROLINA ROENTGEN RAY SOCIETY
Secretary, Dr. Major Fleming, Rocky Mount, N. C. Annual meeting at time and place of State Medical Society. Mid-year scientific meeting at place designated.

CENTRAL NEW YORK ROENTGEN RAY SOCIETY
Secretary, Dr. C. F. Potter, 820 S. Crouse Ave., Syracuse. Three meetings a year—January, May, November.

PACIFIC ROENTGEN CLUB
Secretary, Dr. L. H. Garland, 450 Sutter St., San Francisco, Calif. Meets annually, during meeting of California Medical Association.

PENNSYLVANIA RADIOLOGICAL SOCIETY
Secretary, Dr. L. E. Wurster, 416 Pine St., Williamsport, Pa. Annual meeting, May, 1939. Exact time and place to be decided.

PHILADELPHIA ROENTGEN RAY SOCIETY
Secretary, Dr. B. R. Young, Temple University Hospital. Meeting first Thursday of each month from October to May inclusive, at 8:15 P.M., in Thompson Hall, College of Physicians, 19 S. 22d St

PITTSBURGH ROENTGEN SOCIETY
Secretary, Dr. H. W. Jacox, 4800 Friendship Ave, Meetings held second Wednesday each month, 4:30 P.M., October to June at various hospitals.

ROCHESTER ROENTGEN RAY SOCIETY, ROCHESTER, N. Y.
Secretary, Dr. S. C. Davidson, 277 Alexander St., Meets on second Thursday from October to May, inclusive, 8 P.M., Rochester Academy of Medicine Building.

ST. LOUIS SOCIETY OF RADIOLOGISTS
Secretary, Dr. W. K. Mueller, University Club Bldg. Meets fourth Wednesday of October, January, March and May, at a place designated by the president.

SAN FRANCISCO RADIOLOGICAL SOCIETY
Secretary, Dr. L. H. Garland, 450 Sutter St., San Fran-

* Secretaries of Societies not here listed are requested to send the necessary information to the Editor.

cisco. Meets monthly on first Monday at 7:45 P.M., alternately at Toland Hall and Lane Hall.

South Carolina X-Ray Society
Secretary, Dr. Hillyer Rudisill, Jr., Roper Hospital, Charleston. Meets in Charleston on first Thursday in November, also at the time and place of South Carolina State Medical Association.

Tennessee Radiological Society
Secretary, Dr. F. B. Bogart, 311 Medical Arts Bldg. Chattanooga, Tenn. Meets annually at the time and place of the Tennessee State Medical Association.

Texas Radiological Society
Secretary, Dr. H. C. Harrell, 517 Pine St., Texarkana, Texas. Next regular meeting in Temple, Texas, 1939.

University of Michigan Department of Roentgenology Staff Meeting
Meets each Monday evening from September to June, at 7 P.M. at University Hospital.

University of Wisconsin Radiological Conference
Secretary, Dr. E. A. Pohle, 1300 University Ave., Madison, Wis. Meets every Thursday from 4:00–5:00 P.M., Room 301, Service Memorial Institute.

Virginia Radiological Society
Secretary, Dr. V. W. Archer, University Hospital, University, Va. Meets annually in October.

Cuba

Sociedad Cubana de Radiologia y Fisioterapia
Secretary, Dr. Francisco Padron, Enrique, Villuendas 64, Havana, Cuba. Meets monthly in Havana.

British Empire

British Institute of Radiology Incorporated with the Röntgen Society
Meets on the third Thursday of each month, from November to June inclusive, at 8:15 P.M., at 32 Welbeck St., London, W. 1, or as advertised.

Section of Radiology of the Royal Society of Medicine (Confined to Medical Members)
Meets on the third Friday of each month during the winter at 8:15 P.M. at the Royal Society of Medicine, 1, Wimpole St., London, W. 1.

Section of Radiology and Medical Electricity, Australasian Medical Congress
Secretary, Dr. H. M. Cutler, 139 Macquarie St., Sydney, New South Wales.

Radiological Section of the Victorian Branch of the British Medical Association
Secretary, Dr. Keith Hallam, St. George's Hospital, K.E.W., Melbourne, E. 4, Victoria, Australia. Meets monthly from March to Nov. incl. for scientific discussion.

Canadian Association of Radiologists
Secretary, Dr. A. C. Singleton, Medical Arts Bldg., Toronto, 5, Ontario.

Section of Radiology, Canadian Medical Association
Secretary, Dr. C. M. Jones, Inglis St., Ext., Halifax, N.S.

Radiological Section, New Zealand British Medical Association
Secretary, Dr. Colin Anderson, Invercargill, New Zealand. Meets annually.

Continental Europe

Belgian Society of Roentgenology
Secretary, Dr. J. Boine, Avenue des Alliés, 134, Louvain (Belgium).
Meets monthly on second Sunday at d'Egmonds Palace, Brussels, except in the summertime.

Sociedad Espanola de Radiologia y Electrologia
Secretary, Dr. J. Martin-Crespo, Fuencarral, 7, Madrid, Spain. Meets monthly in Madrid.

Société de Radiologie Médicale de France
Meets monthly on second Tuesday, except during months of August and September, 12 Rue de Seine, Paris.

Société Suisse de Radiologie (Schweizerische Röntgen-Gesellschaft)
Secretary for French language, Dr. A. Grosjean, La Chaux de Fonds.
Secretary for German language, Dr. Scheurer, Molzgasse, Biel.
Meets annually in different cities.

Société Francaise d'Electrothérapie et de Radiologie Médicale
Meets monthly on fourth Tuesday, except during month of August and September, 12 Rue de Seine, Paris.

Association of German Roentgenologists and Radiologists in Czecho-Slovakia
Secretary, Dr. Walter Altschul, German University, Prague, 11.52.

Deutsche Röntgen-Gesellschaft (Gesellschaft für Röntgenkunde und Strahlenforschung)
Meets annually in April, alternating one year in Berlin, one year in some other German city. Meets in addition every two years with the Gesellschaft deutscher Naturforscher und Aerzte.
Permanent Secretary, Professor Dr. Haenisch, Klopstockstrasse 10, Hamburg, Germany.

Süd- und Westdeutsche Röntgensellschaft
Meets annually in different cities.

Nord- und Ostdeutsche Röntgengesellschaft
Meets annually in different cities.

Dutch Society of Electrology and Roentgenology
Holds two meetings a year in Amsterdam, one in the Spring, and one in the fall.

Societa Italiana Radiologia Medica
Secretary, M. Ponzio, University of Turin, Prof. Turin

Societatea Romana de Radiologie si Electrologie
Secretary, Dr. Oscar Meller, Str. Banul Mărăcine, 30, S. I., Bucuresti, Roumania.
Meets second Monday in every month with the exception of July and August.

All-Russian Roentgen Ray Association, Leningrad, USSR in the State Institute of Roentgenology and Radiology, 6 Roentgen St.
Secretaries, Drs. S. A. Reinberg and S. G. Simonson, Meets annually.

Leningrad Roentgen Ray Society
Secretaries, Drs. S. G. Simonson and G. A. Gusterin.
Meets monthly, first Monday at 8 o'clock State Institute of Roentgenology and Radiology, Leningrad.

Moscow Roentgen Ray Society
Secretaries, Drs. L. L. Holst, A. W. Ssamygin and S. T. Konobejevsky.
Meets monthly on the first Monday at 8 o'clock, the place of meeting being selected by the Society.

Polish Society of Radiology
Secretary, Dr. Jan Kochanowski, 45 Gornoslazka St., Warsaw. Meets annually.

Warsaw Section, Polish Society of Radiology
Secretary, Dr. B. Krynski, 11 Zielna St.
Meets once a month except in the summertime.

Scandinavian Roentgen Societies
The Scandinavian roentgen societies have formed a joint association called the Northern Association for Medical Radiology, meeting every second year in the different countries belonging to the Association. Each of the following societies, with exception of the Denmark Society, meets every second month except in the summertime:

Society of Medical Radiology in Sweden
Meets in Stockholm.

Society of Medical Radiology in Norway
Meets in Oslo.

Society of Medical Radiology in Denmark
Secretary, Dr. G. Biering, Copenhagen.
Meets the second Wednesday of each month from October to July in Copenhagen, at 8 o'clock in the State Institute of Roentgenology.

Society of Medical Radiology in Finland
Meets in Helsingfors.

Vienna Roentgen Society
Meets first Wednesday of each month, at 6:30 P.M. at Zentral-Röntgen Institut des allgemeinen Krankenhauses Alserstrasse 4.

Orient

Japan X-Ray Association
c/o Orthopedic Surgery, Tokyo Imperial University. Meets annually in April.

Kinki Roentgen-Abend Society
Director, Dr. Prof. Taiga Saito, Ogawaoike Tyoto Japan. Meets bi-monthly on third Sunday.

THE SCIENTIFIC EXHIBIT

The Scientific Exhibit at the Thirty-ninth Annual Meeting of the American Roentgen Ray Society in Atlantic City was excellent in every detail. The committee responsible for this essential part of the meeting was composed of Dr. S. W. Donaldson, Dr. Elwood E. Downs, and Dr. Vincent W. Archer as chairman. A brief résumé of the various exhibits follows.

Among the exhibits having to do with the skeleton was one on "Causalgic Backache" prepared by Dr. Percival A. Robin, Otto C. Hudson, and Dr. Carl A. Hettesheimer, Hampstead, New York. This was an attempt to prove a clinical syndrome of low back pain on an anatomic basis. Examination reveals a postural scoliosis, a pelvic tilt toward the affected side with apparent lengthening and internal rotation of that extremity, and shortening of the opposite extremity. In the roentgen examination (1) a supine film of the dorsolumbar spine establishes the normal for the patient; (2) an upright film of the same region shows structural adjustments indicated by the increase in the acuity of the angle found by the twelfth rib of the affected side with the spine, and a pelvic tilt; (3) an upright film with elevation of the heel on the affected side shows a return to normal.

The next exhibit in this group was on "Roentgenologic Studies on Various Forms of Chronic Arthritis" by Dr. Haig H. Kasabach, and Dr. M. Henry Dawson, Department of Roentgenology and Arthritis Clinic, Presbyterian Hospital, New York City. In this study, rheumatoid arthritis and osteoarthritis are considered as separate roentgenologic entities. Charts and films were used to demonstrate the following: rheumatoid arthritis; osteoarthritis; tuberculous arthritis; gout; gonorrheal arthritis; rheumatoid spondylitis (another form of rheumatoid arthritis); Still's disease (juvenile rheumatoid arthritis); psoriasis arthropathica; neurotrophic joint disease; pulmonary osteoarthropathy.

An exhibit by Dr. G. Wagoner and Dr. E. P. Pendergrass of the University of Pennsylvania, Philadelphia, was entitled "Anatomic and Roentgenologic Consideration of Anterior and Posterior Notching of the Vertebral Bodies in the Newborn." This consisted of charts with diagrams, photomicrographs and transparencies, also roentgenograms, illustrating the vertebral vascular channels both in the infant and in the adult. The notching in the vertebral bodies resulting from these vascular channels were clearly demonstrated. This exhibit should prove of distinct value in teaching and in explaining the findings frequently noted in roentgen examinations.

In the section on the urinary tract Dr. Robert A. MacArthur of Detroit, Michigan, had an exhibit on "Hematuria" consisting of transparencies illustrating practically all of the pathologic conditions causing hematuria. Included were roentgenograms, cystograms, pyelograms, drawings, cystoscopic views in color and colored photographs. The compilation of these findings was presented in a most attractive and instructive manner and was of great value.

"Lateral Pyelography" by Dr. E. L. Shifflett and Dr. D. Y. Keith of Louisville, Kentucky, was planned to illustrate the interrelation of gross pathology, pathologic behavior, and physiologic variation in the diagnosis of acquired and developmental lesions of the urinary tract, with special emphasis on the usefulness of the lateral pyelogram.

Dr. Henry K. Taylor, Sea View Hospital, New York City, presented the subject of "Renal Tuberculosis." Destructive lesions of the kidney of a tuberculous nature were illustrated, with the genesis of the lesion, and the various points of origin of the infection in the kidney. Many of the cases included the roentgen findings, with photographs of the gross specimen.

In the section of neurosurgery Dr. Cornelius G. Dyke and Dr. Leo M. Davidoff of the Neurological Institute, New York City, had an exhibit entitled "Chronic Subdural Hematoma: A Roentgenographic and Pneumo-encephalographic Study." A

series of 24 cases of subdural hematoma was studied. Papilledema and roentgenologic evidence of increased intracranial pressure were rare. The pineal shadow, on the other hand, was often markedly displaced. Certain changes in the skull occurred in a group of younger patients, which indicated a long-standing hematoma upon which was superimposed evidence of a more recent bleeding. In the older group, with the usual type of chronic subdural hematoma, variations in the skull were absent, but the pneumo-encephalograms indicated an intracranial mass separate from the brain and capable of changing its contour.

"The Demonstration of Space-taking Lesions in the Spinal Canal by Subarachnoid Injections of Oxygen" by Dr. Barton R. Young and Dr. Michael Scott, Temple University Medical School and Hospital, Philadelphia, consisted of an exhibit of illustrations of the normal subarachnoid space in children and adults and of various types of deformities and defects of the spinal canal produced by tumors and other space-taking lesions, particularly cartilaginous disc hernations. A special feature of this exhibit was the demonstration of the position of the herniated disc with the patient in extreme hyperextension and hyperflexion. The normal variation in length of the lumbocaudal sac was also shown.

An exhibit by Dr. Eugene Freedman and Dr. Henry Stiles of the University Hospitals, Cleveland, Ohio, on "Encephalographic Findings in Head Injuries" consisted of encephalograms showing changes in the ventricular system and subarachnoid spaces of the brain caused by gliosis, hematoma, and arachnoiditis as a result of head injuries.

The "Roentgenologic Evidence of Brain Lesions" was presented by Dr. Bernard H. Nichols and Dr. Joseph C. Root, Cleveland Clinic, Cleveland, Ohio, by means of skull films, encephalograms and ventriculograms.

In the division of obstetrics was an exhibit on "Internal Dimensions of the Female Pelvis: Roentgenographic Measurements of Obstetrical Cases" by Dr. Robert P. Ball, Presbyterian Hospital, New York City. This was a quantitative study of more than three hundred female pelves based upon measurements of internal dimensions of the pelves in obstetrical cases. An effort was made to correlate racial characteristics, type of deliveries and volumetric ratio between the size of the fetal cranium and the internal dimensions. This represented an exhaustive study and innumerable calculations, and was a worth while contribution to the roentgenologic field.

The purpose of an exhibit by Dr. J. Fierstein, Greenpoint Hospital, New York City on "Roentgen Pelvimetry without Use of Special Instruments" was to show that any roentgenologist, without special equipment or accessories, can do pelvimetry rapidly and easily. Also to suggest that roentgen pelvimetry should be carried out much more often, and that it may become almost routine in primiparas, at least. Theoretical and practical bases were explained.

In another exhibit on the same subject by Dr. Richard Manges Smith and Dr. Karl Kornblum it was shown how the roentgenologist can be of help to the obstetrician in solving some of the problems occurring during pregnancy. The technique employed in the examination of the maternity patient was outlined, its simplicity making it available to every roentgenologist. Some important information that can be obtained is the detection of pelvic deformities, determination of the nature and position of the presenting part, location of the placenta, the diagnosis of placenta previa, multiple pregnancy, fetal death, deformities of the fetus, polyhydramnios and a variety of other conditions. It was pointed out that roentgenography occupies an important position in obstetrical diagnosis.

In an exhibit by Dr. William Snow and Dr. Meyer Rosensohn, Bronx Hospital, New York City on "Roentgen Visualiza-

tion of the Soft Parts of Pregnancy" were included both films and colored transparent drawings demonstrating the possibilities of diagnosing many of the obstetrical complications.

In the section on the chest was an exhibit on "The Clinical Value of Visualization of the Cardiac Chambers, the Pulmonary Circulation and the Great Blood Vessels in Man" by Dr. George P. Robb and Dr. Israel Steinberg, New York City. In this work diodrast is injected into the basilic or the cephalic vein and roentgenograms are made. The superior vena cava and the right auricle can usually be visualized in from one to one and one-half seconds. The right ventricle and pulmonary artery can be outlined in from three to five seconds. The various positions used were shown and the deformities of the thoracic cardiovascular system due to disease were also demonstrated. This represented an original contribution and was of distinct value both from the pathological and physiological point of view.

An exhibit by Dr. Aubrey O. Hampton and Dr. Benjamin Castleman of the Departments of Roentgenology and Pathology, Massachusetts General Hospital, Boston, was entitled "Correlation of the Upright Post-mortem Chest Teleroentgenogram with Autopsy Findings." In this were shown the technique of the roentgenologic and pathologic examinations and comparative ante-mortem and post-mortem roentgenograms of the normal and more common pathological conditions in the chest. Particular emphasis was placed upon the correlation of the pathologic and roentgenologic aspects of pulmonary embolism and infarction. Included were (1) charts showing pathogenesis, incidence and location; (2) complete presentation of the pathology by diagrams, gross specimens, stained and mounted (actual size) histologic preparations; (3) clinical cases illustrating importance of roentgen findings, and (4) differential diagnosis.

In an exhibit by Dr. G. E. Pfahler, Dr. B. P. Widmann and Dr. H. W. Ostrum, Philadelphia General Hospital, Philadelphia, on "Mediastinal Primary Tuberculous Lymphomata in the Adult and Its Relation to Hodgkin's Disease" were included reductions from 14″ by 17″ films of chests in which the diagnosis of tuberculous lymphoma was made either clinically or microscopically. This disease is a relatively rare form of primary tuberculosis occurring in the adult, and is frequently incorrectly diagnosed.

In the group of exhibits dealing with the abdomen was included one on "Acute Intestinal Obstruction: Treatment by Small Intestine Intubation" by Dr. William Osler Abbott, Dr. Charles G. Johnston, Dr. R. J. Noer, Dr. Grover C. Penberthy, Dr. J. E. Lofstrom and Dr. J. C. Kenning, from the University of Pennsylvania, Philadelphia, and Wayne University College of Medicine, Detroit. This showed clinical histories of patients with intestinal obstruction, photographs of roentgenograms before and after treatment, and of roentgenograms indicating the nature and location of the lesions, kymographic tracings of the activity of obstructed intestine. There was a moving picture film giving technique of treatment, and balopticon with slides showing advantages of this form of therapy. This exhibit represented an exhaustive study and was a distinct contribution to the diagnosis and therapy of intestinal lesions.

Dr. Bernard P. Widmann and Dr. J. Stauffer Lehman, Philadelphia, presented a "Roentgen Demonstration of Gastric and Duodenal Ulcers with Compression Technique." This was a mounted film demonstration of gastroduodenal roentgenograms pointing out routine non-compression appearances of normal and pathological cases as compared with compression "spot film" studies of the same cases. It emphasized the additional information obtainable by the use of compression techniques with special reference to gastric and duodenal ulcer. Certain cases with normal appearances by routine techniques show definite organic lesions by means of compression.

An exhibit by Dr. John L. Kantor, New York City, was entitled "The Roentgen Diagnosis of Idiopathic Steatorrhea" and included photographs of the patients, and roentgenograms made during the gastrointestinal examination. The so-called "moulage sign" was shown and characteristic roentgen changes in sprue and allied conditions associated with steatorrhea were illustrated.

In the section on therapy Dr. William A. Evans and Dr. T. Leucutia, Harper Hospital, Detroit, Michigan, presented an exhibit on "The Value of Deep Roentgen Therapy in Mammary Carcinoma." This consisted of colored photographic transparencies, roentgenograms, charts and graphs, showing the classification, operative and irradiation procedures, and the final results obtained in carcinoma of the breast. The conclusion was reached that radiation therapy represents a powerful agent in both the operable and inoperable group.

Dr. J. E. Kelly and Dr. D. Arnold Dowell, Creighton University School of Medicine, Omaha, Nebraska, had an exhibit entitled "Roentgen Treatment of Acute Peritonitis with Mobile Apparatus." Included were histories and roentgenograms of cases with peritonitis and other acute infections which had been successfully treated with roentgen irradiation. They demonstrated the possibility of treating these patients with the mobile unit. This work brought out numerous possibilities in roentgen therapy often forgotten in many hospitals.

In an exhibit by Dr. Richard Dresser, Collis P. Huntington Memorial Hospital, Boston, on "Million Volt Roentgen Rays" were included photographs of the electrostatic belt-conveyor generator, designed and built by the Massachusetts Institute of Technology. Physical data regarding depth dose measurements, protection measurements and absorption measurements in various metals were presented. Also certain data were shown on the immediate therapeutic results.

"Sialography" by Dr. John V. Blady and Dr. Alfred F. Hocker, Memorial Hospital, New York City, consisted of a roentgenographic study of the submaxillary and parotid salivary glands by means of lipiodol injection into their respective ducts. The technique was described and fully illustrated. The normal and the normal variations as revealed on the sialograms were presented. The diagnostic roentgen aspects of the various diseases, affecting the salivary glands, such as inflammations, duct and gland obstructions, salivary fistulas, xerostomia, mixed salivary gland tumors, carcinoma (primary and extraglandular), and extraglandular affections were demonstrated and discussed.

"Roentgen Studies of the Nasal Sinuses" was the subject of an exhibit by Dr. Raphael Schillinger, Brooklyn, New York. This correlated the clinical and roentgen data in cases of nasal sinusitis, and showed the advantages of a combined anatomic and functional examination by serial roentgenography with lipiodol. Both films and charts were used to demonstrate the contentions of the author.

Dr. Lawrence Reynolds, Dr. Henrietta S. Hayden and Dr. K. E. Corrigan presented an exhibit on "Diffraction Studies of Human Brain and Nervous Tissues." Included was a drawing showing the general outline of a roentgen machine for this work and a series of diffraction patterns obtained on human brain and nervous tissue and on related tumors.

Dr. Robert B. Taft of Charleston, South Carolina exhibited a "Radium Quantity Meter." This is an instrument for the immediate determination of the number of milligrams of radium in a pack, shipping box or other container. It involves no calculations and no time element but gives an easily readable deflection on a large meter. Two ionization chambers are widely spaced from each other and the container is placed between them, the current being amplified by one ordinary radio tube. The diagram was shown and the electrical factors were described.

Dr. Pedro Farinas of Havana, Cuba, had an exhibit on "Radiological Diagnosis of Pituitary Adenoma." This included photographs, diagrams and encephalograms of cases of pituitary adenoma.

The judges made the following awards: The gold medal was presented to Dr. George P. Robb and Dr. Israel Steinberg, New York City, for their exhibit on "The Clinical Value of Visualization of the Cardiac Chambers, the Pulmonary Circulation and the Great Blood Vessels in Man." The silver medal was given to Dr. Robert A. MacArthur, Detroit, for his exhibit on "Hematuria." The bronze medal was awarded to the exhibit on "Acute Intestinal Obstruction: Treatment by Small Intestine Intubation" by Dr. William Osler Abbott, Dr. Charles G. Johnston, Dr. R. J. Noer, Dr. Grover C. Penberthy, Dr. J. E. Lofstrom and Dr. J. C. Kenning, from the University of Pennsylvania, Philadelphia, and Wayne University College of Medicine, Detroit.

THE COMMERCIAL EXHIBIT

The Commercial Exhibit at the Thirty-ninth Annual Meeting of the American Roentgen Ray Society was well arranged and one of the largest the Society has ever had. All of the equipment was displayed to good advantage and much interest was evinced by those in attendance. The following firms participated in this exhibit: Adlanco X-Ray Corporation, Agfa Ansco Corporation, Buck X-Ograph Company, DuPont Film Manufacturing Corporation, Eastman Kodak Company, General Electric X-Ray Corporation, Kelley-Koett Manufacturing Company, K & B Electric Equipment Company, Machlett Laboratories, Patterson Screen Company, Philips-Metalix Corporation, Picker X-Ray Corporation, Standard X-Ray Company, Charles C Thomas, Victoreen Instrument Company, Westinghouse X-Ray Company, and Winthrop Chemical Company.

NEW OFFICERS

At the recent meeting of the American Roentgen Ray Society held in Atlantic City, New Jersey, the following officers were elected for the year 1938–1939: *President:* Dr. John W. Pierson, Baltimore, Md.; *President-Elect:* Dr. Edward L. Jenkinson, Chicago, Ill.; *First Vice-President:* Dr. William McD. Doughty, Cincinnati, Ohio; *Second Vice-President:* Dr. Cornelius G. Dyke, New York City; *Secretary:* Dr. Carleton B. Peirce, Montreal, P. Q. (re-elected); *Treasurer:* Dr. J. Bennett Edwards, Leonia, N. J. (re-elected); *Historian:* Dr. Percy Brown, Boston, Mass. (re-elected); *Member of the Executive Council:* Dr. Raymond C. Beeler, Indianapolis, Ind.

ANTI-CANCER WEEK

Anti-Cancer Week (Le Semaine Internationale contre le Cancer) is to be celebrated this year in France from November 23 to 30, under the sponsorship of the International Union against cancer, of which Sénateur Justin Godart is President, and with the cooperation of the French Government.

One of the special features of this Anti-Cancer Week is an international celebration to commemorate the discovery of x-rays and radium, as well as the extraordinary developments in physics which followed the discovery of the electron and Hertzian waves. Instructive and interesting scientific sessions will be held at the Palais de la Découverte in Paris and the program is to be divided into four principal sections, as follows:

1. Physics of the Electron
2. Physics and Biological Action of X-Rays
3. Physical and Biological Studies on Radioactivity
4. Physical and Biological Studies on the Hertzian or Short Waves

The famous physicist and Nobel Laureate, Professor Jean Perrin, will preside at these sessions and eminent authorities from all parts of the world will participate.

The entire celebration will be one of the finest public tributes ever rendered to those great pioneers whose discoveries have

been of inestimable value to the human race.

A medal has been made especially for the occasion and information concerning it and the program may be obtained from the General Secretary, Mr. L. W. Tomarkin, 18 rue Soufflot, Paris.

Medal commemorating the discovery of radium by Pierre and Marie Curie. Made for the International Union against Cancer.

PASTEUR LECTURE

The Institute of Medicine of Chicago announces that the Fifteenth Pasteur Lecture will be given in conjunction with the Cancer Research Institute of the Chicago Woman's Club at a public meeting to be held on Tuesday evening, November 22, at 8:15 o'clock in the auditorium of the Museum of Science and Industry, Jackson Park, Chicago. Dr. Ludvig Hektoen, Director of the John McCormick Institute for Infectious Diseases, Chicago, and of the National Advisory Cancer Council, Washington, D. C., will speak on "Progress in the Knowledge and Control of Cancer." Through the courtesy of the Museum of Science and Industry, the medical exhibits will be open specially for this occasion.

THE AMERICAN COLLEGE OF PHYSICIANS

The Twenty-Third Annual Session of the American College of Physicians will be held in New Orleans, with general headquarters at the Municipal Auditorium, March 27–31, 1939.

Dr. William J. Kerr of San Francisco is President of the College and will have charge of the program of general scientific sessions. Dr. John H. Musser of New Orleans has been appointed General Chairman of the Session, and will be in charge of the program of clinics and demonstrations in the hospitals and medical schools and of the program of round table discussions to be conducted at the headquarters.

TEXAS RADIOLOGICAL SOCIETY

The Texas Radiological Society reports a splendid meeting at Hotel Gunter, San Antonio, on Saturday, October 22, with 38 members and several visitors present. The following papers were presented in the scientific program:

President's Address: "Roentgen Therapy in Essential Hypertension." R. G. Giles, M.D.

"Roentgen Therapy in Carotid Sinus Syndrome." C. A. Stevenson, M.D.

"X-Ray Treatment of Pneumonia." Tom Bond, M.D.

"X-Ray Treatment of Sinusitis." C. L. Martin, M.D., and J. R. Maxfield, M.D.

"Economic Problems in Radiology." Mac F. Cahal, Executive Secretary of the Inter-Society Committee for Radiology.

"The Advantages of Preoperative Irradiation of the Breast." E. V. Powell, M.D.

"Irradiation of Epiphyses to Prevent Growth of Bone." Davis Spangler, M.D.

The following officers were elected for the coming year: *President:* Jerome H. Smith, San Angelo; *President-Elect:* C. F. Crain, Corpus Christi; *First Vice-President:* M. H. Glover, Wichita Falls; *Second Vice-President:* G. D. Carlson, Dallas; *Secretary-Treasurer:* Henry C. Harrell, Texarkana. The next meeting will be held at the Hotel Doering, Temple, Texas, in 1939. The exact date will be announced later.

LONG ISLAND RADIOLOGICAL SOCIETY

At the twenty-fourth regular meeting of the Long Island Radiological Society held on May 26, 1938, the following officers were elected: *President:* Dr. Samuel G. Schenck; *Vice-President:* Dr. G. Henry Koiransky; *Treasurer:* Dr. Louis Goldfarb; *Secretary:* Dr. Marcus Wiener.

PACIFIC ROENTGEN CLUB

The Pacific Roentgen Club, at its recent annual meeting at Pasadena, elected the following officers for the ensuing year: *Chairman:* Dr. Lyell C. Kinney, San Diego; *Member of the Executive Committee:* Dr. Irving S. Ingber, San Francisco; *Secretary-Treasurer:* Dr. L. Henry Garland, San Francisco.

ANNOUNCEMENT

Word has been received that Prof. Dr. Gottwald Schwarz, an honorary member of the American Roentgen Ray Society, is no longer in Vienna but has established his residence at 68 Compayne Gardens, London, N.W. 6, London, England.

CONFERENCE OF EASTERN RADIOLOGISTS

The annual midwinter Conference of Eastern Radiologists will be held on Friday and Saturday, February 10 and 11, 1939, in Washington, D. C. Headquarters will be at the Hotel Mayflower. For information, write the Secretary of the Local Committee, Dr. Joseph F. Elward, 1726 Eye St., N.W., Washington, D. C.

CONFERENCE OF MID-WESTERN RADIOLOGISTS

The anuual clinical Conference of Mid-Western Radiologists will be held on Friday and Saturday, February 10 and 11, 1939, in Detroit, Michigan, at the Hotel Book-Cadillac. The program usually presented at these meetings consists chiefly of subjects of clinical importance with roentgenological features. Information concerning the conference may be obtained by writing the General Chairman, Dr. E. R. Witwer, Harper Hospital, Detroit, Michigan.

BOOK REVIEWS

Books sent for review are acknowledged under: Books Received. This must be regarded as a sufficient return or the courtesy of the sender. Selections will be made for review in the interests of our readers as space permits,

Medical Uses of Radium: Summary of Reports from Research Centres for 1936. Medical Research Council, Special Report Series, No. 226, Paper. Price, 1s.0d. Pp. 41, with 6 illustrations. London: His Majesty's Stationery Office, 1937.

Great Britain is extremely fortunate in having had the foresight, immediately after the war, to organize the Medical Research Council, the British Empire Cancer Campaign and the National Radium Commission. All three of these bodies, independently and in cooperation, by grants or subsidies, have done a great deal to stimulate research in medicine, in chemistry and in other branches of science. Moreover, this stimulation has contributed greatly toward keeping Great Britain in the forefront of medical research, and this applies to radiology as much as to any other branch.

This report by the Medical Research Council is a summary of progress made during the year by various investigators in the field of radiology and also of the number of cases of malignant tumors of all kinds treated by the more important hospitals in the British Isles which give special attention to the treatment of malignant processes. Among the latter are included the Royal Infirmary, Aberdeen; Birmingham General Hospital; St. Vincent's Hospital, Dublin; King's College Hospital, London; Marie Curie Hospital, London; Middlesex Hospital; Royal Free Hospital; St. Bartholomew's Hospital; the University College Hospital, London; and the Royal Infirmary, Cardiff (Wales).

In the experimental section Professor Paneth reports continued work on the spectroscopic and manometric measurement of helium produced by the neutron bombardment of boron. The sources of neutron were glass tubes filled with finely powdered beryllium and radon. To appreciate the delicacy of these measurements it is only necessary to mention that the largest quantity of helium measured in this series of experiments was $2.4 \pm 0.2 \times 10^{-7}$ cc. of helium. This work has been continued by using gamma rays for the production of helium in beryllium.

Dr. J. R. Tillman, of the Department of Physics of the Imperial College of Science and Technology, completed investigations begun in 1935 on the effect of low temperature upon the capture of slow neutrons by lithium, boron and cadmium. The purpose of these experiments was to elucidate an apparent discrepancy between the increased absorption and the relatively small changes reported by some other workers. The discrepancy was traced to differences in the arrangements employed for cooling the neutrons.

Dr. P. B. Moon, by irradiating a large block of wax as uniformly as possible with fast neutrons and comparing the flux of the resulting slow neutrons at the surface with the flux in the interior, found that the latter was about thirteen times more intense. This result agreed with theoretical predictions and indicated that biological effects of neutrons are likely to be internal rather than superficial. A systematic survey of the effects of changes of temperature between 90 and 290 degrees absolute on the absorption of neutrons into the nuclei of a large number of elements was begun by Dr. Moon and Mr. J. A. Saxton, and is now being carried on by Mr. Saxton and Mr. J. L. O. G. Michiels. All the elements so far studied have shown increased absorption when the neutrons are cold, but the percentage of increase has been found to vary from about 20 per cent for iodine to about 50 per cent for bromine, barium and aluminium.

Dr. W. V. Mayneord, of the Royal Cancer Hospital, has continued and completed his experiments on the standardization of gamma-ray dosage and the attempt to utilize the international roentgen in measuring the quantity of gamma rays. These experiments have confirmed the previous estimate that the ionization produced in one hour by a point source of 1 mg. of radium element, at a distance of 1 cm. and filtered with 0.05 cm. of platinum, is equivalent to 8.3 r. Most of the experiments were carried out with ionization chambers made of materials having a small atomic number. It was shown that secondary scattered radiation from the walls of the ionization chamber, together with the absorption in the walls of the chamber, may be eliminated by extrapolation to zero wall thickness, and the results

were in accord with theoretical investigation. The secondary radiation from the walls, floor and ceiling of the room in which the measurements were made, was found to be negligible, except for chamber-radium distances more than about 25 cm. The question of stray ionization has been systematically studied and it has been found that by using an evacuated system errors were negligible. It has also been found that, as far as the wall of the ionization chamber is concerned, carbon magnesium and paraffin wax gave slightly different results. It was also found that with increasing wall thickness the ionization current reached a maximum and then fell slowly. Also, that with a chamber of finite size the point of measurement was normally very close to the geometrical center of the chamber, but that, when the distance from the source to the chamber was very small, complex errors occurred which were in accord with mathematical and physical theories. As for the measurement of radium content of the source, this was found to be the most inaccurate feature of standard gamma-ray measurements, and very different results may be obtained according to the method of investigation. The effects of wall thickness and material of the chamber with which the quantity of radium was measured were investigated in detail. Another point which was investigated was the directional effects in cylindrical ionization chambers. It was found that, even with chambers of equal length and diameter, there were small differences of the order of 1 per cent in the ionization observations. In connection with the variation of ionization current with wall thickness for sources of various filtrations, it was found that with different filtrations changes of wall thickness have varying effects.

Dr. J. E. Roberts and Miss J. Honeyburne carried out experiments on the distribution of radiation around a ring source in air and water with the ring both on the surface of the water and completely immersed. It was found that the theoretical distribution around the ring was in good agreement with the experimental distribution in air, but in water significant variations occurred according to the position of the ring and the scattering mass. These workers have also undertaken to investigate the problem of the distribution of quality of gamma radiation in a scattering medium, and the results so far seem to show that the average wave length of the radiation received at a point increases as this point moves away from the radium source. Complete interpretation of the results was still impossible, however.

Dr. Spear and Dr. Glückmann, at the Strangeways Laboratory, of Cambridge, have continued their experiments on the effect of gamma rays on the tadpole, and among other things they have found that mitotic activity can be reduced and held in check by radiation, by fasting and by chilling. Also, gamma radiation causes a degeneration of cells only in the mitotic regions of the tadpole and in those areas to which recently divided cells normally migrate; fasting only caused degeneration among cells which were in the process of differentiating, while chilling (not below 5° C.) did not cause any degeneration but produced a gradual diminution in cell division by slowing down various cellular processes, particularly the entry of cells into mitosis. A temperature of 0.5° C. stopped cells in the actual process of mitosis, especially those which were in the metaphase. If warming occurred, such as by removing the animals to room temperature for an hour, the entry of new cells into mitosis greatly exceeded the number of mitotic cells which could complete the process; the result was that the mitotic count reached fantastic proportions with an enormous preponderance of metaphases. After determining quantitatively how each of these agents affected cell division when applied singly, experiments were made in which irradiation was combined with fasting and chilling. It was found that for the doses employed irradiation was effective in producing degenerate cells only when mitosis was rather active or approaching a state of activity. Quantitative studies on the occurrence of degenerate cells made it possible to determine the approximate time required for the complete absorption of the injured cell by its neighbors. When the tadpoles reached the stage of metamorphosis the resorption time was greatly accelerated. Wherever degeneration was caused by irradiation, diminution in the mitotic current preceded the process of disintegration. This was probably accounted for by the effect of gamma rays on cells about to divide, which unfitted them for the ordeal of mitosis.

Other experiments were carried out to compare the effectiveness of single and multiple irradiation of the same total dosage. The preliminary results showed that the efficiency of the divided dose is determined chiefly by

the length of the interval which separates the exposures.

Experiments carried out by Dr. Lea in collaboration with Low Temperature Research Station on the action of gamma radiation on bacteria showed that under certain circumstances the irradiation of bacteria growing in a nutrient medium leads to the production of abnormal forms. The conclusion was reached that, in addition to its lethal action, radiation in large doses has the property of inhibiting division without hindering increase of volume of individual organisms. Thus the organisms grew but, prevented from dividing, became longer and longer until they were eventually killed by the radiation. The lethal action was not reversible and proceeded independently of whether the nutrient material was or was not present in the culture medium. This inhibition of division was only temporary.

During an investigation by Dr. J. C. Mottram, of the Mount Vernon Hospital and The Radium Institute, in which squamous cell epitheliomas produced in mice by tar were exposed to gamma radiation applied at the surface, it was often observed that the cancer cells lying deep and in contact with the stroma presented much greater signs of injury (degeneration, pyknosis, etc.) than more superficial cells, in spite of the fact that the deeper cells were farther away from the radium and had thus received a smaller dose of radiation. As a possible explanation it was thought that the cells nearer the stroma have a more abundant oxygen supply on account of their proximity to blood vessels and for this reason are more radiosensitive. From this it was deduced that tumors composed of small cell masses should be more radiosensitive than those with large cell masses. However, while this deduction may be valid as far as it applied to tumors of the same pathologic variety, it certainly could not apply to tumors of different varieties.

Dr. Mottram has developed a method of spacing radiation in the treatment of tumors, basing the method on two facts: (1) that cells under anaerobiosis are radioresistant and that radiation by action on capillaries and small blood vessels interferes with the circulation of irradiated tumors and by thus bringing about anaerobic conditions causes them to become radioresistant. This conception is interesting but it certainly cannot be accepted as a general explanation of the problem of radioresistance. For example, it does not take into account the fact that radioresistance of a tumor is much more prone to develop after large quantitative doses than when the dose given at any one time has been smaller. If the quantitative dose is sufficiently large to cause a reactive inflammation of the connective tissue, radioresistance is likely to occur much more rapidly than when the quantitative dose is held below the point of inducing reactive inflammation in connective tissue either within the tumor or around it. There is no doubt that radiation effects in blood vessels also may play a considerable part in the problem of radioresistance. According to the method developed by Mottram, treatment is administered only during times of active tumor growth, and is stopped when the growth ceases or when the tumor lessens in size. The treatment is continued over long periods of time, perhaps six months or even more than a year. Each time irradiation is applied a dose of about 500 r is given. The time between successive treatments varies depending on the growth of the tumor. This may vary between one and several weeks. Thus far, only a limited number of hopeless cases of cancer have been treated. A number of tumors have been made to disappear locally with no more damage to the skin than temporary epilation and some bronzing.

Experiments based on the fact that bean roots in which mitosis is abundant are more vulnerable than roots in which mitosis is in abeyance have been continued. By causing temporary inhibition of mitosis an opportunity is obtained of spacing two exposures so that in one case both exposures take place during active mitosis, and in the other case the second exposure is applied when mitosis is absent. A single exposure of 210 r in thirty-five minutes caused mitosis to disappear after six hours and to return to normal in twenty-four hours. A second exposure of 210 r was given in one case after six hours and in the other case after twenty-four hours. The first set caused the death of 6 per cent of the bean roots and inhibited the growth of 25 per cent. The second set caused the death of 42 per cent and inhibited the growth of 82 per cent of the bean roots. A continuous exposure of 420 r gave a 14 per cent mortality and 56 per cent showed inhibition of growth. Owing to the rapid fall in mitosis, mitoses were absent during the latter part of the seventy minutes' exposure. It

seemed evident, therefore, that spacing the radiation can produce an increase in biologic effect.

Dr. M. A. C. Cowell, of the Holt Radium Institute, Manchester, continued investigation of minimal lethal doses as applied to lesions on the face. The material used for the moulds, the size of the treated area, and the distance between the radium and the skin were all kept constant. The gamma roentgen unit was used as the unit of dosage and the arrangement of the radium on the moulds was made according to the system of Paterson and Parker. Roentgen rays were measured in international roentgens. In measuring the reactions of the skin, symmetrical areas on the anterior aspect of the two thighs of the same patient were used. The difficulty in these experiments arose from the clinical observation that even tumors which are histologically similar show a difference in radiosensitiveness within a range of about 100 to 200 roentgens; for this reason, each point had to be established by treating several lesions with the same dose and for the same time. For small rodent ulcers irradiation for the approximate minimal lethal dose was found to be between 1,500 and 2,000 roentgens given in two hours' time, 2,000 r when given within seven and one-half hours, 2,900 r when given within twenty-four hours, 3,600 r when given within seventy hours, and 4,500 r when given within 168 hours. For small skin epitheliomas the approximate minimal lethal dose was 3,000 r when given within twenty-two hours, 3,200 r when given within twenty-four hours, 4,300 r when given within eighty-four hours, 5,000 r when given within 168 hours, and 5,200 r when given within 336 hours.

Several other interesting experiments were conducted by Dr. Colwell and Dr. Gladstone, at the Barnato Joel Laboratories of the Middlesex Hospital, and by Professor Russ and Miss Scott, but space forbids mention of them.

A. U. Desjardins

A Symposium on Cancer. Addresses by Leiv Kreygerg, Det Norske Radium Hospital, Oslo, Norway; Clarence C. Little, Director Roscoe B. Jackson Laboratory for Cancer Research; Madge T. Macklin, Assist. Prof. of Histology and Embryology, Univ. of Western Ontario; Edgar Allen, Prof. of Anatomy, Yale School of Medicine; Howard B. Andervont, Biologist, U. S. Public Health Service, Harvard Medical School; James Ewing, Prof. of Oncology, Cornell University Medical College; Gioacchino Failla, Physicist, Memorial Hospital, New York; Henri Coutard, Curie Institute, Paris; Warren H. Lewis, Dept. of Embryology, Carnegie Institution of Washington; Stanley P. Reimann, Director of Research Institute, Lankeman Hospital, Philadelphia; James B. Murphy, Director of Cancer Research, Rockefeller Institute and Emil Novak, Assoc. Gynecologist, Johns Hopkins Medical School. Cloth. Price, $3.00. Pp. 202, with several illustrations. Madison: University of Wisconsin Press, 1938.

The seventeen papers collected for this book were read before the Cancer Institute held under the auspices of the School of Medicine of the University of Wisconsin, September 7–9, 1936. They deal, for the most part, with the relation of inheritance to cancer, the etiology of cancer, and cancer as a public health problem. Discussions of biopsies by Ewing, of cervical carcinoma by Novak, and of cancer of the breast by Coutard are the only clinical papers in the symposium. The relationship of genes, chemicals, endocrine secretions, viruses, bacterial products, chronic irritation and extrinsic factors to the etiology of malignant tumors are exhaustively considered and to this is added a lengthy philosophical treatise, but when the reviewer had labored through all of this material he was left with the distinct impression that the essential facts had somehow been omitted. Certainly none of the factors thus far considered can be singled out as specific.

Failla's excellent paper on "The Influence of Wave Length on the Biological Action of Radiation" will interest all radiologists and Ewing's discussion of "Cancer as a Public Health Problem" contains much food for thought. The remainder of the book constitutes a comprehensive introduction to the laboratory side of the study of the cancer problem and should receive the attention of those who have not kept abreast of the progress made in this field.

Charles L. Martin

Cutaneous Cancer and Precancer: A Practical Monograph. By George M. MacKee, M.D., Professor of Clinical Dermatology and Syphilology and Director of Skin and Cancer Unit, New York Post-Graduate Medical

School and Hospital, Columbia University, and Anthony C. Cipollaro, M.D., Associate in Dermatology, Skin and Cancer Unit, New York Post-Graduate Medical School and Hospital, Columbia University. With a Foreword by Francis Carter Wood, M.D. Cloth. Price, $3.75. Pp. 222, with 232 illustrations. New York: American Journal of Cancer, 1937.

This small volume is an excellent atlas of tumors of the skin. It is equally divided into two parts of about 100 pages, each devoted to precancerous and malignant lesions. The authors are to be commended for the large number of photomicrographs of high quality used to illustrate the microscopic appearances of practically every condition covered by the book. Sixteen different skin lesions which may be forerunners of neoplasms of a serious nature are included in the first section and basal cell epithelioma, squamous cell epithelioma, Paget's disease, Bowen's disease, malignant melanoma and sarcoma are described in the second section.

A sketchy chapter of 16 pages which discusses methods of treatment in very general terms concludes the volume. A careful description of actual cases successfully treated by the various techniques and illustrated by photographs could be advantageously added and a chapter on the paths and frequency of occurrence of metastases with a discussion of the results obtained from the various forms of treatment available would also enhance the value of the book.

The student who wishes to familiarize himself thoroughly with the clinical and microscopic appearance of precancerous and malignant skin conditions will find this treatise a very valuable addition to his library.

Charles L. Martin

Siebzehn Jahre Strahlentherapie der Krebse, Zücher Erfahrungen 1919–1935. Von Hans R. Schinz and Adolf Zuppinger. Paper, price M. 32; bound, price M. 34, minus 25 per cent in United States. Pp. 340, with 95 illustrations. Leipzig: Georg Thieme, 1937.

The authors report their results in 2,529 patients treated for malignant tumors at the Röntgen-Institute of the Kantonsspital (University of Zürich). The Institute is now serving more than before in the fight against cancer as a radiotherapeutic center for the various departments of the hospital division of the University and for physicians in that part of Switzerland surrounding the city of Zürich.

Of the cases admitted there were 30 per cent of cancer of the upper air and food passages, 16 per cent of the mamma, 10 per cent of the esophagus, 10 per cent of the stomach, intestine and abdominal organs except the ovaries, while 5 per cent were of the skin and natural openings of the body and 1 per cent of the uterus, most of the latter two groups being treated in other departments. This arrangement took away from the Institute those cancer patients which are known to respond best to irradiation. On the other hand, tumors of the upper air passages were referred in comparative abundance after the year 1928, when the Röntgen-Institute could demonstrate satisfactory results in hitherto incurable cases. Rarely were early cases of cancer of the skin referred, and the uterus cases were far advanced. Only 24 per cent (600 cases) were at an operable stage, while 76 per cent (1,929 cases) were inoperable at the time referred.

Twenty per cent of the material received combined surgical and radiation treatment, and 80 per cent radiation therapy alone; of the latter group treatment with roentgen rays was indicated in 85 per cent and with radium in 15 per cent. In purely palliative radiation therapy, roentgen treatment plays a greater rôle than radium therapy except in esophageal cancer.

The different methods of irradiation are explained. Roentgen treatment: in one short session (cancer of the skin)—fractionated in a short period (for palliation)—the rarely indicated protracted-fractionated irradiation in a short period—fractionated doses given over a longer period, the protracted-fractionated roentgen therapy over a longer period (Coutard *et al.*). Radium treatment: interstitially in body cavities (uterus, etc.) and with molds. They are illustrated by clinical examples, photographs and tables, giving a clear picture of those procedures.

In a detailed survey the tumors of the systems and organs are classified. In most instances the two periods of 1919–1928 and 1929–1935 are discussed separately as well as the whole period of seventeen years, January 1, 1937 being the date for checking the results.

In the evaluation, lost cases have been counted as having died from cancer, however more than 98 per cent of all patients could be followed. The strict and sincere statements as to the successes and failures make this book a valuable document. It also demonstrates the greater accomplishments of the improved technique after 1928.

Eighteen per cent (i.e., 43 per cent in the operable and 9 per cent in the inoperable cases) of the patients were symptom-free or dead from intercurrent diseases three years after beginning of treatment; after five years the figure drops to 13 per cent. Including palliative results 70 per cent of all patients showed a positive effect of radiation therapy.

These results were obtained in a radiation department of forty beds. The necessity of clinical observations and care by the radiologist is held indispensable for a successful fight against cancer.

H. F. Plaut

DEPARTMENT OF TECHNIQUE

Department Editor: Robert B. Taft, M.D., B.S., M.A., 105 Rutledge Ave., Charleston, S. C.

A CUFF BALLOON FOR THE RETENTION OF BARIUM ENEMAS*

By C. F. INGERSOLL, M.D.
GRAND RAPIDS, MICHIGAN

MOST roentgenologists have encountered the patient who cannot retain a barium enema, and in whom visualization of the colon is imperative. The present apparatus will permit visualization of the colon in patients where the ordinary methods have failed.

Patients most likely to expel the barium are:

1. The very young.
2. The very old with loss of sphincter control.
3. The ignorant who inexcusably soil their own clothes, gowns and apparatus.
4. The slightly irrational patient.
5. Those no longer having a sphincter due to operative procedure.

Besides the retention of barium there is an additional use for the apparatus not anticipated in its initial purpose.

1. The performance of double contrast studies in:
   a. The elderly patient who can retain barium but not air.
   b. Children who cannot retain either barium or air.

Materials.

1. Penrose drain medium size 5/8 inch diameter or large size 7/8 inch diameter, and 3½ to 4 inches long.
2. Wooden dowel pin 3/4 inch to 1 inch in diameter for the medium or large drain, and 5 inches long.
3. Small strip of No. 0 sand paper.
4. No. 10F soft rubber catheter.
5. Inner tube patch kit in which the rubber remains as one piece and has not been cut into patches.
6. A pair of cuticle scissors.

Instructions for Cementing.

1. The usual preparation of a rubber joint with gasoline, benzine, or other solvents is omitted, as this reduces the elasticity of the rubber.
2. The surfaces to be cemented to one another are prepared by gently rubbing with grade No. 0 sand paper until a slight roughening is obtained.
3. The rubber cement is applied to one of these surfaces in a thin layer and allowed to dry for five minutes; the other surface is then brought in apposition with it.
4. These remain in contact for five more minutes before any tension is applied to the joint.

In Figure 1, *1*, the penrose drain is drawn over one of the fingers and rolled off for three-fourths its length after the manner of a finger cot. This will facilitate rolling the drain on the dowel.

For the sake of clarity in the following description the edge of the drain toward the top in *1* will be denoted "the distal edge"; that toward the bottom "the proximal edge," regardless of the folding that ensues in the subsequent stages.

The proximal edge is "prepared" for a distance of ½ inch. Figure 1, *2*, shows the distal edge folded downward, the proximal

* From the University of Michigan, Department of Roentgenology, Ann Arbor, Michigan.

edge folded upward. In Figure 1, *3*, the proximal edge is drawn up over the distal edge to create an overlap which subsequently will form the seam; one should attempt to keep this in the center. In Figure 1, *4*, the proximal edge is then rolled back, the distal edge is "prepared," and the cement is applied. The proximal edge (Fig. 1, *5*) will now easily roll over the cemented surface and the seam is formed. While this is drying a piece of the inner tube patch is cut, corresponding in length and circumference to the rubber cuff on the dowel. The entire outside surface of the cuff is now "prepared" and cement applied. The inner tube patch is wound around the cuff and any excess is cut off (Fig. 1, *6*).

After this seam has set the entire affair is rolled off the dowel. In doing so it will be turned inside out, and the inner tube patch will lie on the inside of the cuff balloon. This is the proper relationship.

Cutting the hole for the insertion of the catheter is a difficult procedure (Fig. 2). One edge of the cuff balloon is folded back ½ inch in the manner of rolling up one's sleeves; the edge formed by this maneuver is "button-holed" just large enough to admit the catheter when the hole is put on a moderate stretch. The cut should pass through the tire patch rubber and the drain immediately beneath it, but not through the next layer of drain as this would be entirely through the balloon.

The end of the catheter is snipped off just proximal to the eye, this portion is prepared, and cement applied for ½ inch. The catheter is inserted into the hole in the balloon for 3/8 to ½ inch, and a moderate amount of cement is applied at its point of

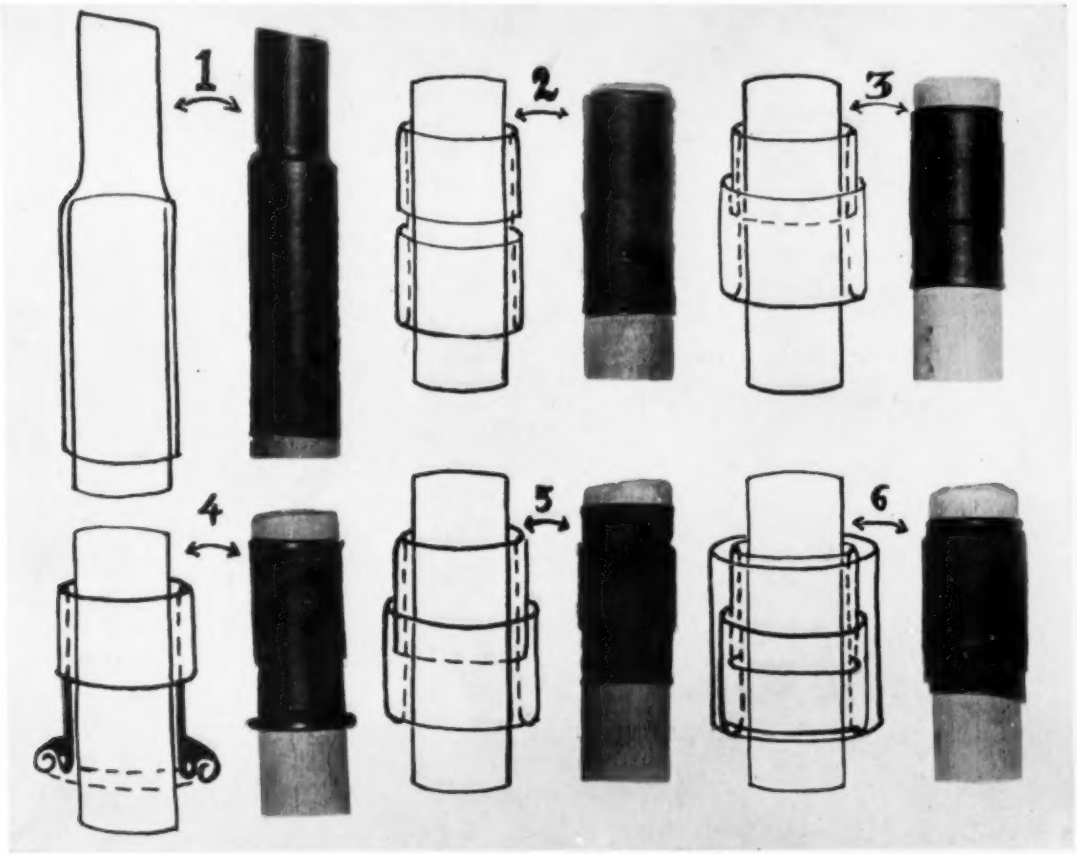


Fig. 1. Method of folding the penrose drain and the tire patch on the dowel.

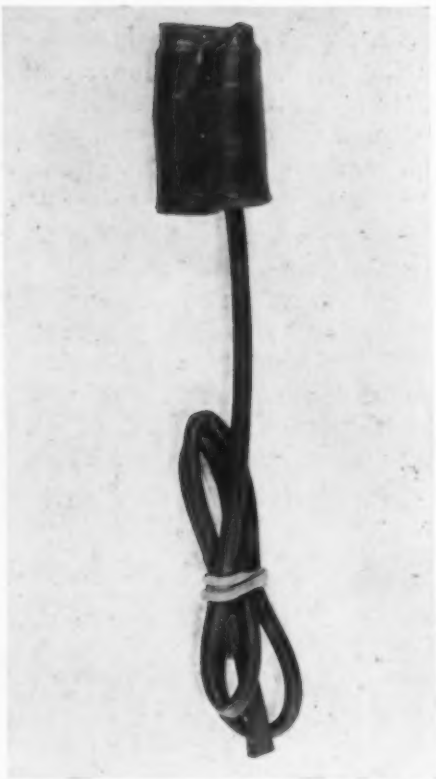


FIG. 2. The finished cuff balloon with the catheter cemented in place.

entry. This joint should set for one-half hour. The balloon may now be tested for leaks by inflating it with a Luer syringe. One side usually distends more than the other. If this occurs the over-distended side is squeezed to distend the under-inflated portion. By such a molding process the rubber may be made to inflate symmetrically.

A Carman barium enema cannula is obtained, and the threaded hub on the shaft is unsoldered by holding this end in the flame of a Bunsen burner. As soon as this end falls off the excess solder on the shaft of the cannula is wiped off, then the cannula is allowed to cool.

The cuff balloon is slid on the shaft of the cannula until it lies just behind the shoulder of the nozzle portion. A second portion of penrose drain 4½ to 5 inches long is rolled in the manner of a finger cot, and starting at the nozzle end this is unrolled, so that it covers the nozzle, passes over the cuff balloon, and ends about 1 inch distal to it. A rubber band is wound about this latter penrose drain just behind the holes in the nozzle, and the free edge is turned back like a cuff.

Figure 3 shows the balloon arranged as just described and distended with fluid.

Early in the development of the device, it was discovered that the compressibility of air permitted the patient to herniate the apparatus from the rectum. Water was found to be ideal. To produce visibility, the water may be made radiopaque by adding 0.5 to 1.0 per cent sodium iodide. This permits roentgenoscopic visualization of the distended balloon and the location of the metallic nozzle.

It is also advisable to construct a sponge rubber washer (2 inches in diameter and ½ inch thick) which will fit snugly on the shaft of the cannula just in front of the usual

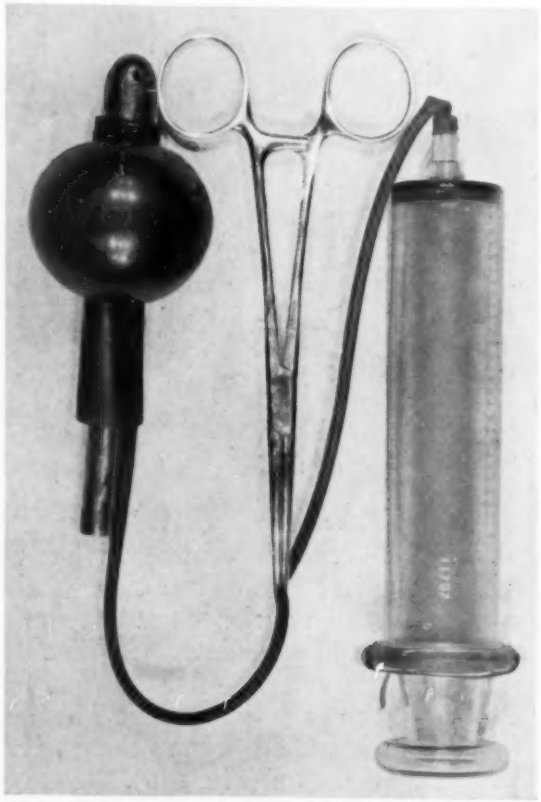


FIG. 3. The cuff balloon on the Carman cannula covered with the extra penrose drain and distended with fluid.

metallic flange bearing the set screw. In the more difficult patients this may be brought against the anus externally, and the sphincter is caught between the balloon on the inside and the rubber washer on the outside.

Ordinarily the procedure is simple. A short piece of rubber tubing is applied to the shaft of the cannula and thence, through a glass connector, to a longer rubber tube which passes to the enema can. The deflated apparatus is covered with petrolatum for lubrication. Water vehicle lubricants are unsatisfactory.

The apparatus is inserted until the cuff balloon lies about ½ inch beyond the rectal sphincter. Under roentgenoscopic control the balloon is distended to the size of a small orange. The usual amount required is 60 to 80 cc., though as much as 130 cc. has been used without untoward effect. The ability of the patient to retain barium is tested. If no further distention is required the catheter is clamped and the enema given. The short rubber tube on the cannula is clamped, then the glass connection is pulled out. If it is necessary to do the roentgenography in an adjoining room, the patient may walk from one room to the other without loss of any solution. The apparatus is best removed with the patient on the stool or a bedpan, for as soon as the balloon is deflated, the barium generally gushes forth.

Fig. 4. Double contrast study in an irrational adult.

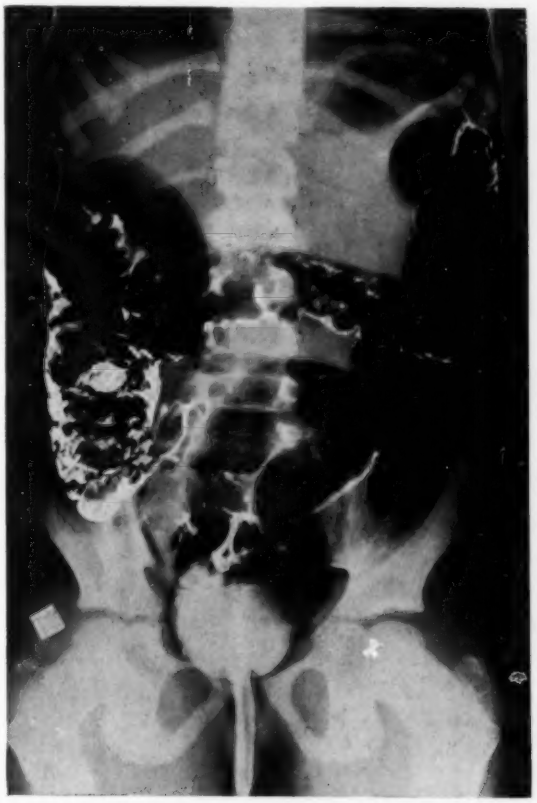


Fig. 5. Double contrast study in an eight-year-old child.

The entire outfit is washed in soap and water. The outer cylinder of penrose and the rubber band are discarded, and fresh ones used at the next examination.

Unfortunately, the seams in the cuff balloon are so-called "cold seals" and will not stand boiling, hence it is necessary to sterilize it by soap and water and soaking in alcohol.

Making of the balloon requires about one hour. The arranging of the setup for use requires at the most five minutes for each patient.

Precautions and Dangers. In a series of 30

examinations, there have been no adverse effects. The operator must be guided by the patient's complaints of pain and his own clinical judgment. This procedure falls into the same category as retrograde injection of the kidney pelvis by means of a syringe, i.e., both have potential dangers.

In the illustrations of its use on patients, it will be noted that only air injections have been demonstrated with the thought that if the patient can be forced to hold air, he will also be able to retain fluid.

Figure 4 is the roentgenogram taken after air injection of a moderately irrational patient with a brain tumor. It was this particular patient who stimulated the construction of the cuff balloon. Three barium enemas by the ordinary method were successful to the beginning of the sigmoid colon only. At this point the barium was always expelled. The patient's colon was subsequently injected with both barium and air. Due to the space limitations for publication, the multiple diverticula in the sigmoid area are not shown. The marked spasm in this area is well demonstrated. It was undoubtedly the irrationality of the patient plus the marked irritability of the colon which made the ordinary method ineffectual.

Sigmoidoscopy of an eight-year-old girl had demonstrated a solitary polyp. It was desirable to rule out the possibility of a congenital colonic polyposis by means of a barium enema. In spite of great effort to cooperate, the child was unable to hold the barium. With the aid of the cuff balloon, both barium and air were easily retained (Fig. 5). Satisfactory stereoscopic double contrast studies were obtained.

VOL. 40, NO. 5

A METHOD FOR SECURING RADIUM NEEDLES IN THE MOUTH

By HAROLD W. JACOX, M.D., *and* S. GLENN MAJOR, M.D.

From the Departments of Radiation Therapy and Maxillo-facial Surgery of the Western Pennsylvania Hospital
PITTSBURGH, PENNSYLVANIA

THE more mobile portions of the oral cavity and its contained structures do not readily lend themselves to the implantation of radium needles, since it is difficult to maintain them in their correct position. It is usually impossible or impractical to secure them by packing. We have devised a method for maintaining such needles in proper position, which has considerable merit. It is applicable to any part of the oral cavity, including the oropharynx.

The eye of the radium needle is threaded with No. 30 stainless steel wire, the ends are left long, and tied with a triple square knot. Heavier wire may be used, but we believe that less trauma is occasioned by employing the finer wire, and yet sufficient tensile strength is provided if ordinary precautions are exercised.

The radium needles are introduced in the usual manner, except that alternate needles, if placed parallel, are introduced end-to-end. If they are introduced in a radial manner, needles opposite to each other are aligned end-to-end. Care should be taken that the wire is not cut by instrument pressure. After the needle has been embedded in the tissue, one end of the wire (*a* in Fig. 1) is threaded on a medium-sized round needle and the point enters at the point of introduction of the radium needle. The wire suture is kept as close as possible to the latter and as it approaches its end the wire suture is brought out into the mouth. Similarly, the alternate needle is introduced and the corresponding end of the wire is brought out into the oral cavity near the needle end. These two wires are tied tightly together, thereby tending to draw the ends of the radium needles together and preventing any possibility of dislodgment. The other ends of the wires attached to either needle are loosely tied together, brought outside the mouth, and

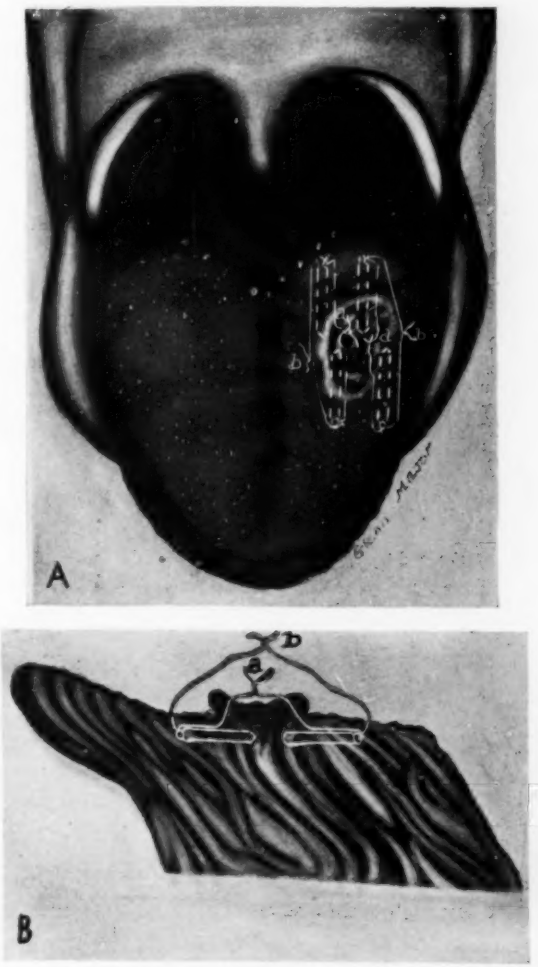


FIG. 1. *A*, dorsal view of four radium needles implanted into the tongue. *a*, wire sutures passing through tissue of tongue and emerging near ends of radium needles, where they are tied together; *b*, other ends of wires tied together. *B*, cross section view of tongue, showing method of placing wires *a* and *b*

anchored to the skin with adhesive tape. It is possible to thus secure as many needles as desired by this method.

In removal of the needles the wire knot at *a* is cut, and the end *b* is grasped with a hemostat, easily withdrawing the needle.

The stainless steel wire is well tolerated by the tissues. One great advantage of such material is the facility with which the needle is embedded, since the knot is much smaller than the caliber of the needle. With reasonable care, radium needles may be implanted in any part of the mouth by this method.

INDEX TO ABSTRACTS

ROENTGEN DIAGNOSIS

Skeletal System

Outland, T., and Hanlon, C. R.: Posterior dislocation of the elbow joint complicated by fracture of the medial epicondyle and ulnar-nerve injury 788

Buxton, St. J. D.: Ossification in the ligaments of the elbow joint 788

Wilson, P. D.: Treatment of slipping of the upper femoral epiphysis with minimal displacement 789

Plummer, W. W.: Comments on internal fixation in fresh fractures of the neck of the femur 789

Harris, R. I.: Experiences with internal fixation in fresh fractures of the neck of the femur 790

Waldenström, H.: First stages of coxa plana 790

Albright, F.: Changes simulating Legg-Perthes disease (osteochondritis deformans juvenilis) due to juvenile myxoedema 791

Goldenberg, R. R.: Traumatic dislocation of the hip followed by Perthes' disease 792

Watson-Jones, R.: The results of postural reduction of fractures of the spine 792

Brown, H. A.. Enlargement of the ligamentum flavum 792

Oppenheimer, A.: Diseases of the apophyseal (intervertebral) articulations 793

Swart, H. A.: Typhoid spine 794

Anderson, H. E.: Pregnancy complicated by osteopetrosis 794

Quaintance, P. A.: Pneumoroentgenography of the knee joint 794

Goisman, J., and Compere, E. L.: The healing of fractures of atrophic bones 795

Ham, A. W., Tisdall, F. F., and Drake, T. G. H.: Experimental non-calcification of callus simulating non-union 795

Geschickter, C. F., and Maseritz, I. H.: Myositis ossificans 796

ROENTGEN AND RADIUM THERAPY

Portmann, U. V.: Classification of mammary carcinoma to indicate preferable therapeutic procedures 796

Chamberlain, W. E., and Young, B. R.: Should the method of Coutard be applied in all cases of cancer treated by roentgen rays? 797

Leucutia, T.: Three-year results in treatment of malignant neoplasms with supervoltage roentgen therapy 797

Martin, C. L., and Moursund, W. H.: Irradiation sickness 798

Charteris, A. A.: Control of local sepsis in radium therapy by use of proflavine oleate 798

MISCELLANEOUS

Elman, C., and Haworth, E.: Thorotrast as a contrast medium 798

Patey, D. H.: Experimental observations on spread of carcinoma by blood-stream 798

Böhme, W.: Small film roentgen cinematography 798

Kirklin, B. R.: Graduate education and training of radiologists 799

Pendergrass, E. P.: Experiences in teaching radiology to undergraduate students 799

Moore, C.: Undergraduate teaching of radiology in the medical schools of the United States 801

von Wieser, W.: Student instruction in roentgenology 801

Holmblad, Edward C.: Postero-anterior x-ray view of knee in flexion 802

Yngve, Nordheim: A new roentgen method for demonstrating the articular cartilages, particularly the knee joint menisci (without using the injection of contrast substances 802

Kerber, Bruno: Experimental studies on venous air emboli 802

Altshcul, Walter: Further experience with radium chloride injections 803

Belot, J.: New tube for radiotherapy at high intensity with an external anticathode .. 803

Spiegler, G.: Roentgen dosimetry, its evolution and present status 803

Strauss, S.: The history of the mekapion and its present-day evolutionary state 804

ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

SKELETAL SYSTEM

Outland, Tom, and Hanlon, C. R. Posterior dislocation of the elbow joint complicated by fracture of the medial epicondyle and ulnar-nerve injury. *J. Bone & Joint Surg.*, July, 1938, *20*, 750–753.

An important and not infrequent complication of posterior dislocation of the elbow is fracture of the medial epicondyle. The displaced fragment may become incarcerated in the joint fissure at the time of reduction, with consequent limitation of motion, and eventually a traumatic arthritis develops. At times the epicondylar fragment is accompanied by the ulnar nerve, and symptoms of a typical ulnar neuritis soon appear. The clinical and roentgenographic findings are quite characteristic, namely, a block to motion, bony in character; ulnar neuritis occurring immediately or within a few days; an extra shadow in the joint space representing the detached fragment; and the absence of the medial epicondyle from its usual place in the roentgenogram.

Operative removal is indicated if closed manipulation is unsuccessful in removing the detached epicondyle from the joint space. Occasionally the ulnar nerve is carried along with the epicondyle, and an immediate or delayed ulnar neuritis may develop. If this occurs operative interference is indicated. If an open operation is required in the treatment of these complications of posterior dislocation of the elbow, removal of the epicondyle from the joint and transplantation of the ulnar nerve anteriorly are the objectives. These particular complications should be kept in mind in cases of posterior dislocation of the elbow joint, especially in children.—*R. S. Bromer.*

Buxton, St. J. D. Ossification in the ligaments of the elbow joint. *J. Bone & Joint Surg.*, July, 1938, *20*, 709–714.

Buxton states that the condition which he discusses in this paper can be termed "arthritis ossificans ligamentosa" of the elbow, a name which corresponds to spondylitis ossificans ligamentosa, the only disease in which there is extensive ligamentous ossification. The formation of bone in muscle about the elbow has received much attention, but it appears that the changes in ligaments are seldom mentioned, although the two are not infrequently associated. Ossification in the ligaments of the elbow joint is usually of traumatic origin and is probably more common than in the ligaments of any other joint. It occurs particularly after dislocation and after injuries to the outer side of the joint. It is seen, but does not necessarily occur, after an operative procedure on the elbow. The causation of the ossification in the majority of cases can be termed, Buxton thinks, mechanical and is due to the avulsion of the attachments of the ligament. One end of the ligament is torn away from the bone and carries with it a small piece of periosteum. A hematoma results and bone cells are activated, so that the torn end of the ligament becomes united to the bone from which it was torn by a piece of bone, or by fibrous tissue in which there is a piece of bone. The quantity of bone formed is dependent upon the treatment. With rest, little or no bone formation occurs, but massage and movements encourage it greatly.

From his study of the records and roentgenograms in cases of severe elbow injury he found in the majority of dislocated elbows which were followed by serious ossification of the ligaments several significant facts: (1) the primary reduction of the dislocation and the first two weeks of treatment were not carried out in an organized fracture clinic; (2) there was a small fracture as well as the dislocation; (3) movement by manipulation under anesthesia or passive movement had been employed subsequent to the primary reduction of the dislocation.

It is noticeable that the ossification of the ulnar collateral ligament is often irregular, so that the roentgenogram shows what is termed "droplet" formation of bone. The cause of this is difficult to explain. In some of the roentgenograms showing this formation, there is quite a space between the droplets and the medial epicondyle. In some cases there is sufficient evidence to show that periosteum had been torn off. Another change which may occur

in the region of the elbow is calcification and not ossification. The deposits apparently occur in the muscle attachment and may be similar to that occurring in the tendon of the supraspinatus and in the tendo achillis.

The existence of large plaques of bone produces stiffness. If the elbow is put at rest as soon as ossification is recognized, the condition may not be painful. Small fragments usually cause slight stiffness and may produce limitation of movement, or there may be no symptoms at all. When there is a piece of displaced bone as well as ossification in the ligament, the limited movement is dependent on the former.

Correct preventive treatment is very important. Immobilization limits excessive bone formation and is therefore advisable. Movement and massage are harmful. Fixation is usually carried out over too short a period; a period from ten to fourteen days does not allow time for the absorption of blood and the healing of the ligaments. Healing requires three weeks and longer in cases where there is much swelling and bruising. When it is recognized that ossification exists in muscle around the elbow, it is fortunate that absorption, either partial or complete, will occur if the part is immobilized. —*R. S. Bromer.*

Wilson, Philip D. The treatment of slipping of the upper femoral epiphysis with minimal displacement. *J. Bone & Joint Surg.*, April, 1938, *20*, 379–399.

The author confines this paper to a study of two phases of slipping of the upper femoral epiphysis: (1) the treatment of early stages of slipping, and (2) the effect of operative fusion of the upper femoral epiphysis upon growth of the lower extremity.

Real slipping of the epiphysis occurs as soon as the epiphysis is loosened, and without slipping it is doubtful if there would be any symptoms. The difference between a case of early slipping and one of severe displacement is merely the degree of deformity. Any attempt, therefore, to fix a boundary between the displacement that is of no serious functional significance and that which is, must be purely arbitrary and approximate. In making a decision, one should be guided not only by the roentgenogram but also by the clinical evidence. More information as to the amount of displacement is usually obtained from the lateral roentgenogram than from films exposed in the anteroposterior plane. When in the anterior view the upper border of the epiphysis appears well above the upper surface of the neck and in the lateral view the epiphysis has not displaced posteriorly more than one-third of the diameter of the neck, then, Wilson believes, the deformity may be safely accepted. He has followed a number of patients who showed this amount of displacement and has seen them recover normal function with the exception of a slight loss of internal rotation. Milch states the first step in the mechanism of displacement is anteversion of the neck in relation to the epiphysis, which produces the characteristic fixed external rotation of the extremity. Only later does the upward displacement of the neck take place, resulting in the typical deformity with the capital epiphysis lying posteriorly and inferiorly.

For epiphyseal slipping with minimum displacement, Wison advocates the insertion of a Smith-Peterson flanged nail under roentgenographic control, without arthrotomy of the hip. The advantages of this method are security and fixation, hastening of epiphyseal fusion, freedom from immobilization, and simplicity of after-care. He has performed the operation in 9 cases with excellent results in all.

Wilson is satisfied that the question of whether there is any effect of early fusion of the epiphysis upon future growth of the extremity is largely academic. He reviewed a series of roentgenograms of patients treated in plaster without any operation and found that the epiphyseal cartilege fused early in any case. Subsequent follow-up examination of the patients whose hips were nailed was reassuring and showed that serious shortening of one extremity did not develop.—*R. S. Bromer.*

Plummer, W. W. Comments on internal fixation in fresh fractures of the neck of the femur. *J. Bone & Joint Surg.*, Jan., 1938, *20*, 97–107.

In this article Plummer comments on the results obtained in a series of 35 patients operated upon for internal fixation of fracture of the neck of the femur. Of these cases, 33 would properly be classed as intracapsular fractures, while 2 were fractures at the base near the trochanter. The ages of the patients ranged from forty-six to ninety-two years. Nine of the patients have died, 2 within the ten-day post-

operative period. The other 7 survived for periods varying from one month to eighteen months, and died of cancer, incorrigible diabetes and other causes due to their senescent state.

The immediate postoperative results in this series would alone, in the author's opinion, be sufficient justification for the internal-fixation operation. The patient is comfortably and easily cared for in bed, he has no pain, and he is completely relieved of the apprehensions of a long and exhausting bedridden period in plaster or traction. Of the 26 patients living, 4 have been operated upon too recently to be considered at this time; the remaining 22 are comfortably ambulatory, their functional ability apparently depending upon their age and general condition, rather than on what might be termed their actual hip function, which seems to be good.

In evaluating end-results, Plummer believes that too much emphasis has been placed on the feature of apparent bony union. Doubt can be expressed with respect to roentgenographic interpretations usually presented as a basis for the reports of a high percentage of cases of bony union resulting from this or that procedure. In older patients he believes that a satisfactory weight-bearing function must be considered as sufficient on the assumption that the fixation nail will be the chief factor in maintaining a useful leg for these patients during the rest of their lives.

The method used to insert the nail in proper fashion is fully described. To save time in calculating the actual neck length in the patient, a graph is used based on a constant height from the tube center to the film in all cases. The position of the operating table and Potter-Bucky diaphragm is such that with fixed and rigid relations of the leg to roentgenographic projection distances and angles, it is possible to insert and drive the right-sized nail at the proper location with complete confidence and assurance that the nail will not go astray.—*R. S. Bromer.*

Harris, R. I. Experiences with internal fixation in fresh fractures of the neck of the femur. *J. Bone & Joint Surg.*, Jan., 1938, *20*, 114–123.

During the past three years, Harris has been treating fractures of the neck of the femur by internal fixation and his experience has been such as to make him an enthusiastic advocate of this method. The principles on which the success of treatment of fractures of the neck of the femur depend is accurate reduction of the fragments, close contact of the fragments and maintenance of position after reduction, without any movement of them whatsoever, during the whole period of healing.

The Smith-Peterson nail is the only form of internal fixation which was used. It was introduced by open reduction; insertion along a previously placed Kirschner wire; and by the use of a long handle screwed into the nail. The importance of good roentgenograms is emphasized. Roentgenograms of the supero-inferior projection are necessary. Portable roentgen-ray equipment of adequate capacity and a technique which will afford good views in two planes are required. Successive sets of roentgenograms from which comparison can be made is advocated which means that each film is exposed from a predetermined position of the tube and cassette. Developing facilities must be within easy reach of the operating room so that films may be examined quickly.

One source of failure is too early weight bearing. Harris reports one complete and one partial failure from this cause. The quality of the steel in the nail is of importance. It is essential that the nail be as non-irritating as possible. Not all stainless steels are suitable for this work. The so-called high-nickel high-chromium alloy has proved least irritating and least likely to corrode. The smoother the surfaces of the nail, the greater is the ability to resist corrosion. There is also danger in using nails that are too long and of driving them in too far, the latter being due to the use of an overlength nail.

Harris states that on the Fracture Service of the Toronto General Hospital nearly all their failures occurred in the early period of the use of this form of treatment. Further experience has demonstrated that the nail can be inserted with increased speed and facility and with greatly diminished disturbance to the patient, and as a result, Harris believes that a nail properly placed in the fragments will ensure union in practically every case in greatly diminished time and with great improvement in function.—*R. S. Bromer.*

Waldenström, Henning. The first stages of coxa plana. *J. Bone & Joint Surg.*, July, 1938, *20*, 559–566.

The etiology of the disease, first described by Legg and the author in 1909, is still unsolved. The names usually given to it, "Perthes' disease" and "osteochondritis deformans" are badly chosen because in the case of the first, Perthes was not the first to describe it. The second name is equally unfortunate because it conveys a wrong idea: the disease is not inflammatory. It is neither an osteitis nor a chondritis. In 1920 the author suggested the name "coxa plana" which, while it takes no account of the etiology, nevertheless describes the deformity, namely the flattened epiphysis. By many authors this designation is used only for the later stages of the disease, because they believe that only then has the head of the femur become flattened. Waldenström states that this is not the case, however. His studies have shown that the flattening of the epiphysis is the principal sign of the pathological process in its very earliest stage. From the study of anatomical specimens it can be determined that the pathological process is a primary necrosis, followed by resorption of the necrotic cancellous tissue, and at last, formation of new bone and cartilage occurs.

The first symptom of the disease is limping, sometimes associated with pain in the hip, or more commonly, toward the knee. The limp is often slight, scarcely noticeable to the eye. Besides the limp there is restriction of mobility sufficient to be measured in degrees when compared with the sound hip. In the beginning this restriction of mobility very soon disappears if the patient is kept in bed. Waldenström has treated 4 cases in which the symptom of limping has been present for some weeks only and the roentgenographic appearance at that time was normal. The roentgenograms were exposed in the anteroposterior plane only and he thinks that lateral views, had they been made, might have shown some changes in the head. He advocates examination in the latter position.

In order to observe in better fashion the early changes he cuts away the central part of the films on which the hip joints and the pelvis have been exposed symmetrically, and places the two joints side by side, as close to each other as possible. Usually the form of the two sockets is identical. If, however, the femoral epiphyses are compared, the epiphysis on the affected side is lower and shows a distinct flattening of the part facing the roof of the acetabulum. In the lateral projection, the flattening is even more apparent. Only the upper anterior portion of the epiphyseal center is flat due to the fact that this part is necrotic. Close inspection shows that, at the top, the upper part of the epiphysis where it looks as if something had been worn away, a thin hardly distinguishable line concentric with the epiphysis can be seen. This narrow strip indicates the position of the joint cartilage. It is visible in the roentgenogram only because a narrow margin of bone has not become resorbed and is therefore still in its place close to the cartilage. Underneath this strip there is a bright zone, caused by a subchondral resorption of necrotic bone. The necrosis may involve more or less of the epiphysis; sometimes, only the upper anterior part; and in the most extensive cases, the whole epiphysis with the adjacent part of the neck. There is also an increase in the distance between the femoral epiphysis and the bottom of the acetabulum. This is caused by the fact the head does not fit the socket and the empty bottom of the socket is then filled with synovia. Waldenström believes the shape of the acetabulum in the early stages is normal and this refutes the theory of Jansen that a congenital variation in the shape of the acetabulum is the primary cause of the disease.

Radical operative treatment is not advocated in the early stages. The patient should be given one to two months rest in bed, after which he is allowed up and about on crutches for at least one year. Plaster and immobilization should never be used, the author believes, because these procedures tend to impair the circulation and nutrition in the joint and may therefore be injurious.—*R. S. Bromer.*

Albright, Fuller. Changes simulating Legg-Perthes disease (osteochondritis deformans juvenilis) due to juvenile myxoedema. *J. Bone & Joint Surg.*, July, 1938, *20*, 764–769.

Albright states that the case he reports in this paper shows that a condition which has the roentgenographic appearance of Legg-Perthes' disease may occur in hypothyroidism and can be cured by thyroid medication. The questions then arise as to how constant such epiphyseal changes are in hypothyroidism and whether all cases of Legg-Perthes' disease are on a hypothyroid basis. From the literature it is clear that lesions occur in the epiphyses of cretins, which are similar to those seen in Legg-Perthes' disease. From the work of

Looser, however, it appears that the pathological changes in the epiphyses in the two conditions are entirely different. Hypothyroidism and, as suggested by Shelton and Cavanaugh, retarded bone age should be looked for in all cases of apparent Legg-Perthes' disease.—*R. S. Bromer.*

Goldenberg, Raphael R. Traumatic dislocation of the hip followed by Perthes' disease. *J. Bone & Joint Surg.*, July, 1938, *20*, 770–774.

Goldenberg reports a case of traumatic dislocation of the hip followed by Perthes' disease. The assumption that there might have been a previous incipient Perthes' disease in his case, the development of which was hastened by trauma, has little support. A careful study of the roentgenograms failed to show any evidence of epiphyseal disturbance or separation. He found 5 cases previously reported in the literature and the occurrence of Perthes' disease in these and in his, the sixth, lends support to the hypothesis of a traumatic origin of Perthes' disease. In treating cases of traumatic dislocation of the hip joint, the possibility of the development of an osteochondritis of the femoral epiphysis should be borne in mind.—*R. S. Bromer.*

Watson-Jones, R. The results of postural reduction of fractures of the spine. *J. Bone & Joint Surg.*, July, 1938, *20*, 567–586.

The author divides fractures of the spine into avulsion fractures of the transverse processes, contusion of the spinous processes and injuries to the vertebral bodies and the interarticular joints. His paper concerns only the latter group. He distinguishes three types of fracture of the vertebral body: (1) simple wedge fracture; (2) comminuted fracture; and (3) fracture-dislocation. The simple wedge fracture is the most common and is due to a fall from a height, landing on the heels or the buttocks. It is often multiple; the intervertebral discs are uninjured and spontaneous ankylosis is rare. The comminuted fracture is the most rare and is caused by forcible acute angulation. The intervertebral discs are ruptured, and bony ankylosis is common. Fracture-dislocation is due to the fall of a weight on the shoulders, and the spinal cord is usually injured.

The author states that the spine must be hyperextended to the normal limit when reduction is attempted. The position varies considerably in different patients, therefore fixed or controlled degrees of extension by slings or curved surfaces are imperfect. The trunk should be entirely unsupported so that it sags into space to the limit of the patient's extension movement.

In the wedge and comminuted types of fractures, excellent anatomical results were obtained by the postural method of treatment. Two-thirds of the author's patients reported that their spines were as good as before they were injured; 80 per cent resumed their original occupations. In fracture-dislocations, immobilization in extension is advisable but laminectomy is not indicated.

Uncorrected wedging causes persistent pain, due to interarticular joint strain. Neglect of minor details of the technique of postural reduction is a cause of failure, according to the author. He advises against the cutting of an abdominal window in the cast and it must not be cut below the clavicles or above the groin. It is safe to allow early walking but the jacket must be renewed after a few weeks. Immobilization should be enforced for four to six months. He advises against posterior spinal supports.

Hyperextension fractures of the spine are very rare. In the 2 cases described, one was a fracture of the vertebral body and the other was a fracture of the pedicles. In fracture-dislocation of the lumbar spine with bilateral dislocation of the interarticular joint, lateral shifting of the spine may lock the articular processes. If the spine is hyperextended, reduction fails and cord injury may be increased by stretching. One and rarely both of the lower articular processes must first be excised.—*R. S. Bromer.*

Brown, Howard A. Enlargement of the ligamentum flavum; a cause of low-back pain with sciatic radiation. *J. Bone & Joint Surg.*, April, 1938, *20*, 325–338.

Enlargement of the ligamentum flavum producing compression of nerve roots is a more common cause of low-back pain with sciatic radiation than has been recognized, the author believes. During the last seven months 7 patients were operated upon with such symptoms, and in all, enlargement of the ligamentum flavum was found.

The most frequent history of injury was of

lifting, in association with flexion and torsion of the spine or a fall on the buttocks. The patient usually described a snapping sensation in the spine followed by pain in the back and, later, gradual radiation of the pain over the sciatic distribution into the thigh, the leg, and the foot. The interval between the onset of pain in the back and radiations into the leg varied from a few hours to several months.

A positive diagnosis of enlargement of the ligamentum flavum can seldom be made from a clinical study only. Spinal puncture and the use of lipiodol are required. An increase in the total protein content of the spinal fluid above 50 mg. per 100 cc., suggestive of an intraspinal pathological process, was present in 3 cases. At least 4 cc. of lipiodol should be used in order to locate a minor defect in the spinal canal. Roentgenographic examination should be made with the patient in the prone position and any defects should be checked by immediate films, without moving the patient. In the absence of abnormalities, the examination should be repeated after an interval of two weeks, to be certain that a defect has not been overlooked. Study of the anatomy of the ligamenta flava shows that even a moderate enlargement may cause compression of the nerve roots. Enlargement occurred between the fourth and fifth lumbar vertebrae in 6 of the patients and at the lumbosacral junction in one. After their exit from the dura, the nerve roots lie in the very narrow space between the ligamentum flavum and the intervertebral disc. Even a slight enlargement of the ligament, a posterior protrusion of the disc, or a combination of the two, will produce compression of the nerve roots. Treatment consists of laminectomy and a wide lateral removal of the enlarged ligament in order to free the nerve root from compression. If the enlargement is generalized as found at operation, the constriction of the dural sac is often striking. In most of Brown's patients rapid relief of pain followed removal of the ligament. If the compression of the nerve root had been prolonged and severe, recovery from the alterations in sensation, motor power, and reflexes was gradual, as is the case in the recovery and regeneration of any peripheral nerve following trauma.—*R. S. Bromer.*

Oppenheimer, Albert. Diseases of the apophyseal (intervertebral) articulations. *J. Bone & Joint Surg.*, April, 1938, *20*, 285–313.

Oppenheimer states that this study had its origin in the commonplace observation that recurrent or persistent pain and stiffness in the spine are not always associated with demonstrable anatomical changes, and that well-marked spinal lesions may be found in the absence of any clinical symptoms. Little is known in this connection about the behavior of the apophyseal joints. Clinically, affections of these articulations do not cause very distinctive local manifestations. Roentgenologically, some of the pathological structures involved are too radiolucent to produce definite shadows, and the inaccessible position of the joints, their complicated structure, and their variable relation to the vertebral bodies render the articulations almost invisible on "routine" roentgenograms.

Special attention is given to the following questions:

1. Can the diseases be classified anatomically or etiologically?

2. Are there demonstrable interrelations between certain clinical and distinct anatomical findings?

3. What are the relations between diseases of the apophyseal joints and affections of other elements of the spine?

4. Can treatment be directed by the results of such diagnostic evaluation?

In his conclusion, Oppenheimer answers these questions as follows:

1. The two main types of arthritis affect also the apophyseal joints. Atrophic spondylarthritis, associated chiefly with focal or general infections, occurs in an acute reparable form in which cartilages are not involved; in a localized chronic type, marked by destruction of cartilage; and as a chronic, more or less systemic disease, ankylopoietic spondylarthritis. Hypertrophic spondylarthritis, marked by destruction of cartilage, but not necessarily by bone hypertrophy, is often the result of persistent changes in the position of the vertebrae; in another type, independent of mechanical factors, it is possibly of infectious origin (amebiasis). Secondary involvement of the articular processes in inflammatory and rarefying diseases of the vertebral bodies is rare. Isolated rarefaction of the articular segments without cartilaginous lesions, another rare condition, is etiologically obscure.

2. Local pain (spontaneous and on pressure) and stiffness caused by muscle tension are

found in active phases of any type of spondylarthritis. Rigidity not caused by muscle spasms develops whenever articular cartilages are affected. Rigidity without pain is observed in quiescent hypertrophic and in arrested ankylopoietic spondylarthritis. In diseases of the vertebral bodies and intervertebral discs, local pain and persistent rigidity occur chiefly when the apophyseal articulations are involved. Radiculitis, which may develop in any disease that affects the interveterbral foramina, is not characteristic of particular lesions.

3. Atrophic spondylarthritis is independent of other systemic spinal diseases; there is especially no correlation either with spondylosis ossificans ligamentosa or with the various types of spondylitis. Hypertrophic spondylarthritis, being intimately related to postural alterations (mainly those resulting from "discogenetic" lesions), is often associated with traumatic changes—hypertrophic spondylitis, scoliosis, and the like.

4. Acute atrophic spondylarthritis can be cured; chronic atrophic spondylarthritis can be arrested by successful treatment of the coexistent infection. In hypertrophic spondylarthritis, the treatment depends upon the underlying lesion (mechanical or infectious).—*R. S. Bromer.*

Swart, H. A. Typhoid spine. *J. Bone & Joint Surg.*, April, 1938, *20*, 473–476.

Swart reports a case of typhoid involvement of the spine, the patient being under observation from the time of onset of the typhoid fever, through the period of active involvement of the spine until the apparent cure was effected. Although case reports of other writers state that such a condition is osteomyelitic in character, his case appeared to be an osteitis rather than an osteomyelitis as there was at no time any evidence of abscess formation. In addition, his patient showed symptoms of involvement of the nerve roots; at one time the knee jerk on the left side was abolished but no sensory changes were noted. The roentgenograms showed destruction of the vertebral discs and adjacent borders of the vertebral bodies. The patient was allowed to go without support at the end of eight months, and he was apparently completely well in one year. Recovery was apparently expedited by traction in hyperextension on a convex frame, and by continuation of the hyperextension by cast and brace.—*R. S. Bromer.*

Anderson, Harley E. Pregnancy complicated by osteopetrosis. *J. Bone & Joint Surg.*, April, 1938, *20*, 481–485.

Anderson reports the case of a woman, aged twenty-six, who complained of weakness, exhaustion, and an amenorrhea of two months' duration. Roentgenograms of the skeleton disclosed typical osteopetrosis of the skull, spine, pelvis and long bones. Inasmuch as this condition is a familial, hereditary disease, observers agree that pregnancy is contraindicated. For this reason, a hysterectomy was done with removal of the fetus and sac intact. Sterilization and ligation of the fallopian tubes, a suspension of the uterus and an appendectomy were done. The patient made an uneventful recovery. Microscopic sections of the fetus were made, but it was too small to show any important osteogenic changes.—*R. S. Bromer.*

Quaintance, Paul A. Pneumoroentgenography of the knee joint. *J. Bone & Joint Surg.*, April, 1938, *20*, 353–362.

A combination of insufflation with oyxgen, carbon dioxide, or atmospheric air and roentgenography in demonstrating and differentiating injuries to and diseases of the soft-tissue structures of the knee has been used successfully as shown by previously reported cases of other writers. Quaintance reports briefly his experience with pneumoroentgenography as such an aid in diagnosis in 50 patients studied during the last seven years. No reports of infections attributable to the procedure have come to his attention. Kleinberg reported a case of non-fatal pulmonary embolism following an unsuccessful attempt at insufflation by a hospital resident.

Under local infiltration anesthesia, with the knee relaxed in slight flexion on the roentgen table, the joint is insufflated with atmospheric air. Any fluid present is aspirated. A moderate degree of distention of the joint is effected by the injection of from 100 to 150 cc. of air with an ordinary Luer syringe and needle with a stop-cock. Stereoscopic anteroposterior and plain lateral roentgenograms are exposed, using a soft tissue detail technique. The air is released, the needle is withdrawn, and a sterile dressing and an elastic bandage are applied.

Hypertrophy of the retropatellar fat pad, indicative of chronic synovitis or injury was demonstrated in 21 knees. The pad was palpably enlarged in only 7 patients. Baker's cysts were shown in 4 knees. Fracture of the meniscus was diagnosed by this method in 71 per cent of the knees in which fractured menisci were found at operation. Displacement of a meniscus was diagnosed in 91 per cent of the knees in which a displaced cartilage was found on arthrotomy. Fracture-displacement of a meniscus was verified by arthrotomy in 100 per cent of the knees in which this diagnosis was made. Loose bodies were diagnosed in 8 knees and removed from 3 knees operated upon. One undemonstrated pedunculated body was found at operation.—*R. S. Bromer.*

Goisman, Joseph, and Compere, Edward L. The healing of fractures of atrophic bones. *J. Bone & Joint Surg.*, July, 1938, *20*, 587–603.

Atrophy of bones of young rats was produced by Goisman and Compere by feeding a diet low in calcium content. The healing of fractures of atrophic bones produced by feeding this diet progressed to the stage of complete bony union at a rate comparable to that observed in animals of a control series fed a normal stock diet. The authors estimated that the total amount of bone laid down in repair was less and the new trabeculae and cortices of the bone were definitely thinner in those animals fed the deficient diet than in those constantly receiving a diet adequate in calcium.

Addition of an excess of vitamin D or calcium carbonate, or both of these elements, to the diet, whether they had been previously on a diet low in calcium or on a normal stock diet, did not hasten the rate or improve the quality of healing of the fracture, as compared with the fracture healing of rats constantly fed the normal stock diet.

Goisman and Compere believe their work presents evidence to indicate that massive doses of calcium and vitamin D by mouth may produce an inhibiting effect on the quality of healing of fractures of normal or atrophic bones. Since the vitamin D requirement for the average human adult is not known, and since massive doses of vitamin D may produce atrophic changes in the bones of experimental animals and delayed healing of fractures, they question the advisability of continuing the practice now becoming common of prescribing massive doses of vitamin D, or of vitamin D and calcium, for patients with fractures, in whom there is no evidence of a deficiency of these elements. They believe there is a real need of a carefully planned and executed long-time study to determine the vitamin D and calcium requirements of the average human adult.—*R. S. Bromer.*

Ham, A. W., Tisdall, F. F., and Drake, T. G. H. Experimental non-calcification of callus simulating non-union. *J. Bone & Joint Surg.*, April, 1938, *20*, 345–352.

Complete bone repair is the outcome of two processes which usually concur—callus formation and calcification. In this investigation, the authors separated these two processes by experimental means, so that they were able to produce uncalcified callus. Fractures were produced in animals which were being fed a diet that deranged their calcium and phosphorus metabolism. At the end of three weeks, roentgenograms gave the impression that no union had occurred, but the histological examination showed the presence of an excellent callus of bony tissue, although it was uncalcified. Similarly treated animals, allowed to live four days longer and given vitamin D during this period, showed a rapid calcification of the bony callus which was, of course, already in existence. This rapid calcification of callus was noted in roentgenograms. The histologic appearance of the fracture changed little in this time.

Non-calcification of a callus is not non-union, because bony union is judged as such by the character and arrangement of the organic constituents of callus and not by its mineral content. The authors believe that vitamin D and other so-called calcifying agents do not control the formation or growth of a callus and only indirectly affect its calcification.

Their experiment clearly separates the two phases of bone repair and illustrates that roentgen appearance of healing can be prevented by a failure of calcification even though a good organic callus is present. This, they think, indicates that it is futile to adopt therapeutic measures directed at one process when the other is at fault, because the two processes are controlled by entirely different factors. The possibility that certain cases of apparent meager or tardy union or even non-union in human beings are in reality cases of non-

calcification should be considered.—*R. S. Bromer.*

Geschickter, Charles F., and Maseritz, I. H. Myositis ossificans. *J. Bone & Joint Surg.*, July, 1938, *20*, 661–674.

The authors review in this paper the clinical and pathological data on 25 cases of myositis ossificans, the series including both the circumscribed and the progressive forms.

Trauma is the most common cause of muscle ossification. The lesion may follow a single mild or severe blow. Dislocations or fracture-dislocations, especially of the elbow, may give rise to these pathological changes. In the series the age of onset varied from thirteen to seventy-two years. Only 2 cases of the progressive form were found in the series of 25. Both cases occurred in females. Trauma plays an important etiological rôle, but, as in the case with the circumscribed type, the cause is unknown. The earliest physical findings consist of a doughy mass which gradually becomes indurated. It may make its appearance within a few hours. The earliest evidence of ossification is manifested in the roentgenogram by small, discrete, dense shadows which lie some distance from normal bone. These areas gradually become confluent and form one large spicule of bone that continues to be separated from the shaft in about three-fifths of the instances. Bone can be seen roentgenographically as early as three weeks, and it reaches its maximum growth in from ten weeks to six months.

The diagnosis is not always simple. Malignancy can often be eliminated only with difficulty. Malignant changes may complicate a benign lesion.

The authors discuss in detail the pathology and histology of the condition, and illustrative roentgenograms and photomicrographs are presented. The analysis of the cases indicates, the authors believe, that the conservative form of treatment is often preferable to the radical form. Postoperative recurrences are common, especially if surgical removal of the tumor is undertaken before six months, or if resection is not complete. Deep roentgen therapy is being tried in a series of cases, but it is still too early to evaluate its usage. Ossification occasionally regresses and, when persisting, is not always a functional or painful disturbance.—*R. S. Bromer.*

ROENTGEN AND RADIUM THERAPY

Portmann, U. V. Classification of mammary carcinoma to indicate preferable therapeutic procedures. *Radiology*, Oct., 1937, *29*, 391–403.

In an effort to bring some order to the chaotic thought regarding the value of irradiation in the treatment of breast cancer, the author has first established a workable clinical pathological grouping of the cases analyzed.

Group I, includes (*a*) tumors definitely localized in the breast and movable; (*b*) skin not involved; (*c*) metastasis not present in axillary lymph glands.

Group II, (*a*) tumor localized in the breast and movable; (*b*) skin not affected (or only very slightly edematous or ulcerated); (*c*) metastasis present in axillary lymph glands but few involved.

Group III, (*a*) tumor diffusely involving the breast; (*b*) skin involved (edematous, ulcerated), multiple nodules; (*c*) metastasis to numerous axillary lymph glands or to other tissue (supraclavicular nodes, lungs, bones, etc.).

In studying all the breast cases operated upon by Crile between 1895 and 1931, it was found that 30 per cent fell in Group I; 25.9 per cent had axillary metastasis with movable tumors (Group II), and 44.7 per cent had advanced carcinoma (Group III). In other words, 70 per cent of all cases had axillary metastasis or more advanced disease at the time of operation. It was also noted that in only one-half of the cases in which axillary metastasis was actually present was such information gained by physical examination.

In evaluating the effect of irradiation, the author took an equal number of cases in each group that were given postoperative irradiation and compared them with a similar number of cases which did not receive postoperative irradiation. He concluded that 90 to 100 per cent of cases in Group I will be cured by surgery alone.

In Group II, with surgery alone, it was found that 47.6 per cent were free from disease at the end of five years and 52.4 per cent were alive at the end of five years with or without disease. When cases in this group were treated postoperatively, it was found that 71.4 per cent were free from demonstrable evidence of cancer and 76.2 per cent were still surviving five years

or more, with or without evidence of this disease. Apparently the explanation of the benefits from irradiation in Group II is not that more patients are definitely cured but that their lives are prolonged by the treatment.

In Group III not one of either the irradiated or non-irradiated group survived the five years without evidence of disease. It was noted that a larger percentage of the patients irradiated were alive from six to twenty-four months after operation than were those not receiving irradiation.

The study justifies the conclusion that patients presenting clinical evidence of advanced mammary carcinoma are incurable from the standpoint of operation alone and that radical surgical procedure can do no good but actually may do harm by shortening their lives.

The clinical manifestations of incurable carcinoma are:

I. Manifestations affecting the skin:
   (*a*) Edema (pig or orange skin) even of moderate degree;
   (*b*) Brawny red induration and inflammation;
   (*c*) Multiple nodules;
   (*d*) Ulceration.

II. Manifestations affecting the breast:
   (*a*) Edema;
   (*b*) Diffuse infiltration;
   (*c*) Multiple secondary tumors;
   (*d*) Fixation of the breast or tumor to chest wall.

III. Manifestations of metastases:
   (*a*) Axillary lymph nodes, numerous or fixed;
   (*b*) Supraclavicular metastases or edema of the arm;
   (*c*) Distant metastases (lungs, bones, other organs).

This is an excellent paper on radiation therapy of breast cancer and should be read carefully by radiologists who are constantly confronted with the question "Does roentgen therapy of breast cancer really do any good?" —*J. H. Harris.*

Chamberlain, W. Edward, and Young, Barton R. Should the method of Coutard be applied in all cases of cancer treated by roentgen rays? *Radiology*, Aug., 1937, *29*, 186–189.

The essential features of the Coutard technique are the frequent doses of relatively small fractions and protraction until the covering epithelium is lost. The authors believe that, within certain limits, other factors such as target skin distance, voltage, filter thickness and r afflux (r per minute) are relatively unimportant.

They recommend this technique in the treatment of slow-growing tumors of epithelial origin. However, highly anaplastic tumors growing rapidly, such as lymphosarcoma of the tonsil, have been better handled by massive dose technique. The rate of recovery in such tumors is equal to or greater than that of the skin and thus they increase in size under the protracted low intensity therapy.

For certain radioresistant tumors with a sensitive blood supply such as fibrosarcomas, neurofibromas, and certain highly vascular tumors such as telangiectatic tumors of the spinal canals, they recommend monthly treatments of from 300 to 800 r (in a three- or four-day series).—*J. H. Harris.*

Leucutia, T. Three-year results in the treatment of malignant neoplasms with supervoltage roentgen therapy. *Radiology*, March, 1938, *30*, 356–360.

A total of 312 cases of malignant disease were treated at Harper Hospital during 1933 and 1934 by supervoltage roentgen therapy, mostly with 500 kv. equivalent radiation, and the author concludes:

(1) If a thorough irradiation with 200 kv. equivalent has led to failure in a certain instance, the supplemental irradiation with 500 kv. produced no material improvement in the final results.

(2) In the cases primarily treated with supervoltage roentgen therapy no change in the law of radiosensitivity was observed as compared to the 200 kv. radiation. It appeared in this respect that there is no direct quality dependence or selective reaction. The groups of malignant tumors which proved unfavorable to the 200 kv. equivalent irradiation continued to remain unfavorable also to the 500 kv. equivalent irradiation.

(3) Primary supervoltage roentgen therapy with or without association of other methods led to better results in all those instances in which the irradiation has been rendered more efficacious, as compared to the 200 kv. equivalent radiation, but in which the malignant process was still of local character although the

invasion by continuity appeared very considerable. The increased efficacy may be attributed to better absorption conditions, signifying an indirect quality dependence or differential action. If all malignant neoplasms are divided into five clinical stages, it is found that supervoltage roentgen therapy has led to definite improvement of the three-year results in Stages III and IV, in those groups which were favorable also to the 200 kv. equivalent radiation. The best example is represented by carcinoma of the uterine cervix in which the percentage of three-year survival was increased from 30 to nearly 60. A similar improvement was obtained in certain bulky skin cancers, in carcinoma of the rectum, in the earlier cases of carcinoma of the prostate, in some types of sarcoma, in carcinoma of the thyroid, and to a lesser extent in metastatic carcinoma of the lymph nodes of the neck.—*J. H. Harris.*

Martin, Charles L., and Moursund, Walter H., Jr. Irradiation sickness. *Radiology*, March, 1938, *30*, 277–284.

A brief general discussion of irradiation sickness is given by the authors. They are of the opinion that some portion of the intestinal tract or the parotid gland must be included in the treated area for serious symptoms to be produced. This sickness is produced by an interference with intestinal physiology. Because anorexia and degenerative changes in the intestinal tract have been reported as caused by a lack of vitamin B_1, the authors began giving this substance to patients under roentgen therapy. The results have been encouraging. The dosage is 2,000 international units daily, beginning two days before the treatments are started. It is felt that a saturation of vitamin B_1 must be obtained and maintained if relief of symptoms is to occur. The medication is given by mouth; however, if vomiting does occur, vitamin B_1, 2,000 international units should be given intravenously.—*J. H. Harris.*

Charteris, Alexander A. Control of local sepsis in radium therapy by the use of proflavine oleate. *Lancet*, Sept. 11, 1937, *2*, 627–628.

The author has had considerable success in cleaning up infections with this drug. When made up in a 1 per cent solution in liquid paraffin or olive oil, proflavine oleate has proved highly bactericidal yet non-irritating to irradiated surfaces. Since the substance is oily, it does not adhere to raw infected surfaces and may be painlessly removed.—*P. J. Hodes.*

MISCELLANEOUS

Elman, Claude, and Haworth, Elizabeth. Thorotrast as a contrast medium. *Lancet*, April 24, 1937, *1*, 981–982.

This is a case report with pathological evidence confirming previous observations that the reticulo-endothelial system is the main site of storage of thorotrast. The histological survey was made five weeks after injection at which time there was evidence of damage to the reticulo-endothelial system. Very little thorium was found in the excretory system. The largest amount was found in the lungs.—*P. J. Hodes.*

Patey, David H. Experimental observations on the spread of carcinoma by the blood-stream, with special reference to the difference between the portal and systemic routes. *Brit. J. Surg.*, April, 1937, *24*, 780–786.

The author has compared experimentally the hematogenous spread of malignant disease by the portal and systemic routes. An emulsion of a carcinomatous tumor was injected into an ear vein for the systemic injection. The portal vein was injected with the abdomen open. The number of animals showing metastatic lesions following portal injection is much less than following systemic injection. This corresponds to the findings in human malignant disease where blood-borne metastases are much more frequent in tumors of systemic territory such as breast cancer and melanotic malignancies than in large bowel malignancies which apparently spread through the portal system. The author suggests that the liver and lung act as barriers to the spread from the portal system. It is probable that the reticulo-endothelial system plays a prominent part in the resistance to blood-borne metastases.—*P. J. Hodes.*

Böhme, W. Über Röntgenschmalfilmkinematographie. (Small film roentgen cinematography.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, Jan., 1938, *57*, 59–64.

Janker developed the method of indirect roentgen cinematography with an apparatus produced by Siemens. This method has advantages over kymography in showing extremely rapid movements with complicated

changes in form. The author has used both methods to show the movement of contrast substances in the circulatory system of animals and demonstrate his discoveries regarding the important function of the auriculoventricular diaphragm in the propulsion of blood. Latest developments permit taking up to one hundred and fifty pictures a second. The film used is especially sensitive to yellow-green light and provides good contrast even when given one-fourth the optimum exposure. The usual fluoroscopic screen was employed with a yellow-green color. The tube factors employed were 80–90 kv., 100–75 ma., and 3–4 seconds exposure time for experiments on the thorax of cats. Using 80 kv., and 50 or 30 ma., 24–32 pictures could be taken a second for 10–20 seconds.—*W. A. Evans, Jr.*

Kirklin, B. R. Graduate education and training of radiologists. *J. Am. M. Ass.*, Aug. 28, 1937, *109*, 633–634.

Until 1934 when the American Board of Radiology prescribed certain fundamental requirements in the education of radiologists, there was no uniform base on which courses of instruction in radiology could be constructed. The American Board of Radiology requires that the student shall be a graduate from a medical school recognized by the Council on Medical Education and Hospitals of the American Medical Association, and after 1940 it will be required that he shall have completed an internship of not less than one year in a hospital approved by the Council. His special training in radiology shall comprise not less than three years of study in an institution recognized by the Board and the Council and shall include (*a*) intensive graduate training in pathologic anatomy, radiophysics and radiobiology, (*b*) active experience of not less than twenty-four months in the radiologic department of the institution, and (*c*) examination in the basic sciences and clinical aspects of radiology. The Board has not attempted to plan a detailed course but has established broad minimum requirements. Methods of teaching are not prescribed.

Among all factors involved, the most important is the selection of students for training. It is essential that the student be young, industrious and keenly interested in radiology and have a natural aptitude for the work. A natural aptitude for radiology is indicated by keenness of observation, marked ability in analysis, a well-restrained imagination and a highly judicial temperament.

Not less than six months should be devoted to the study of pathologic anatomy, three to technique, twelve to diagnostic interpretation, nine to therapy and six to any branch in which the student is keenly interested or in which he feels that he is deficient. A thorough knowledge of pathologic anatomy is an indispensable foundation for efficient roentgen diagnosis and treatment. The twelve months devoted to roentgen diagnosis should be applied to attentive observation in this field, to comparison of roentgen diagnoses with conditions found at operation or necropsy, and, whenever possible, to active participation in special procedures. Training in radiotherapy, including both roentgen and radium therapy, should consist of practical instruction in measuring dosage and selecting appropriate techniques, together with as much supervised experience as can safely be granted to the student.

As to methods of instruction, the student should get his knowledge from experience by active participation in the work rather than from didactic teaching. The informal seminar is highly instructive. The radiologic department should have a special library that is readily accessible. All didactic methods should be secondary and supplementary to active, closely supervised participation in the work.

The student should not fail to maintain and enlarge his knowledge of other fields of medicine. He should be deeply impressed with the fact that he is to become a consultant in virtually all branches of medicine. Consequently he should attend meetings of the institutional staff and special lectures by leaders in medicine, note the results of medical or other treatment, and familiarize himself with the principles, applications and effects of various surgical procedures. By this extension of interest he will become far more capable both as radiologist and as counselor.—*S. G. Henderson.*

Pendergrass, Eugene P. Experiences in teaching radiology to undergraduate students. *J. Am. M. Ass.*, Aug. 28, 1937, *109*, 634–637.

In the teaching of radiology at the University of Pennsylvania School of Medicine radiologic methods of teaching, wherever they will assist

in giving the student a better understanding of his problem, have been emphasized.

In the first year the class in anatomy is divided into groups of eight students. Each of these groups receives three roentgenoscopic demonstrations, including the movements of the thorax and diaphragm, the heart and great vessels, the digestive tract and the various articulations and movements of the joints. The work is supplemented by the use of suitable roentgenograms. This work is conducted by the professor of anatomy and his staff.

The professor of physiology and his staff use roentgenology in teaching physiology to students by the demonstration of stomach and intestinal movements in animals and in individual students. In teaching pathology by means of roentgenology, one of the members of the department of radiology tells the students what roentgenology contributes in the diagnosis of the various pathologic lesions, with demonstration of illustrative films. This work in physiology and pathology is given during the second year.

In the teaching of applied anatomy during the third year the members of the department of anatomy make constant reference to roentgenograms in the work on the chest, with emphasis on the differences between the anatomy of the dissecting laboratory and the anatomy of the living thorax. Roentgenograms are used also for studying the distribution and rearrangement of various structures, which may be so investigated because of their roentgen opacity or their ability to be injected with a radiopaque medium.

The entire third year class is given an elementary course in radiology, consisting of sixteen hours of didactic lectures. Holmes and Ruggles' "Roentgen Interpretation" is used as a textbook. An attempt is made to teach the students to value both the potentialities and the limitations of the roentgen examination, as well as those conditions in which its use is essential. Emphasis is placed on the correlation of clinical and roentgen observations, rather than presenting a tremendous number of slides of various pathologic conditions. In addition to the foregoing, a few lectures are given on roentgen and radium therapy. Here again the fundamental principles of the effects of irradiation on various tissues are stressed.

During the fourth year the students become clinical clerks in the hospital wards. The general approach to radiologic teaching is a correlation of the clinical and the roentgenological observations on patients seen by these students in the wards of the hospital. The teaching is divided into medical, pediatric, general surgery, urology and neurosurgery groups. A radiological and clinical conference is held for the medical section group once a week, in which an hour is devoted to the presentation of the case history, the physical and roentgen observations and a discussion of diagnostic possibilities or therapeutic approach. A radiologic-pediatric conference meets once a week for one hour. Roentgenologic aids in surgical diagnosis and treatment are presented at a weekly one hour conference, divided into general surgery, urology and neurosurgery. In the general surgery group, students are required to present a brief abstract of the clinical history and physical examination concerning current cases in the hospital wards. The films are presented and the cases discussed clinically by some member of the staff. The roentgen diagnosis of urologic conditions has been presented in a more didactic way because of the special nature of the examination, the unfamiliarity of the average student with observations by intravenous or retrograde pyelography and the lack of a proper selection of current cases. In neurosurgical diagnoses much the same procedure is used as in urologic teaching. Because of the unfamiliarity of the student with roentgen examinations of the skull, it is necessary to review roentgen anatomy. Indications and contraindications for encephalography and ventriculography are presented.

In addition to the above, teaching of the students on the surgical trimester has recently been extended to include ward rounds, one hour each week; pathologic conferences, two hours every fifth week, and elective tumor conferences, one hour each week. On ward rounds a general introduction is given to radiation therapy. In pathologic conferences the rationale and arguments for the type of therapy used in certain cases are fully discussed. In the elective tumor conferences patients with unusual tumors are shown. During these demonstrations the type of pathologic process and therapeutic procedures are discussed. At other times the end-result of a therapeutic procedure is demonstrated in order to illustrate what can be expected in the treatment of certain malignant conditions.—*S. G. Henderson.*

Moore, Claude. Undergraduate teaching of radiology in the medical schools of the United States. *J. Am. M. Ass.*, Aug. 28, 1937, *109*, 637–640.

To determine the status of the teaching of radiology, a survey was made by review of all the catalogues of all the medical schools in the United States giving a full four-year course and rated as grade A by the Council on Medical Education and Hospitals of the American Medical Association. The information secured from these catalogues was checked with the information furnished by the last Educational Number of the *Journal of the American Medical Association* and the latest list of the Diplomates of the American Board of Radiology. There are sixty-eight class A medical schools giving at least a full four-year course and an M.D. degree. An attempt was made to determine both the quality and the quantity of teaching that was offered, as well as the importance of this specialty in each school. Forty of the medical schools had a separate radiologic department organized under a separate head and equal in rank with the other departments in the school. The size and the rank of the staffs in radiology are even more variable than the amount of space describing radiology in the catalogues. Thirty-six medical schools give the rank of full professor to one or more members of the faculty in their departments of radiology. The size of the staffs of the radiologic departments of the different medical schools vary all the way from one to ten members. In some of the large university medical schools the department of physics and experimental biology is closely affiliated with the radiologic staff. The ability of the faculty can be judged only by the professional connections of its members. The only information available was the latest list of the Diplomates of the American Board of Radiology. In six of the medical schools no member of the faculty was a diplomate of this board. According to the American Board of Radiology, twelve medical schools do not have staffs sufficiently well trained to use radium in the treatment of disease. In some other schools, it is only the junior members of the radiologic staff that are members of this board. It is almost impossible to judge, with any degree of accuracy from the catalogues, the amount of radiologic instruction given medical students by the medical schools. Seven medical schools teach radiology in all four undergraduate years. Five more schools have courses in three different years. The other medical schools are about equally divided in number as to instruction in one or two years.

All sixty-eight medical schools were checked with the latest roster of hospitals giving a residency in radiology accepted by the Council on Medical Education and Hospitals. Thirty-two medical schools have no connection with these hospitals, leaving thirty-six that are affiliated. It was felt that, when a medical school has connections with a hospital radiologic department giving a residency in radiology, both the quality and the quantity of instruction available to students would be superior to those schools having no such connections.—*S. G. Henderson.*

von Wieser, W. Der Studentenunterricht in der Röntgenologie. (Student instruction in roentgenology.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, March, 1938, *57*, 221–230.

The present-day importance of roentgenological aid in diagnosis is brought out by the following statistics from the practice of medicine in Vienna. In 1936, 13,790 cases were cared for in the beds of the Allgemeine Krankenhaus, and of these 9,591, or 69.5 per cent, had roentgen examination or roentgen treatments. In a group of 120,000 ambulant patients, members of a workers insurance society with salaried physicians and their own Röntgeninstitut, there were 45,051, or 38 per cent, such patients. In another type of insurance society which was in professional and financial difficulties there were 4.3 per cent of 418,668 patients (with 140,000 members in the society!). In view of the high cost of roentgen examination and treatment and the necessity for minimum expenditure for the economic type of patient treated, the author believes that the figures represent the lowest possible figures for the modern practice of medicine.

Roentgenology is of course being taught everywhere, but the importance and time given to it and the manner of teaching differ in every place. Four reasons are given to account for the little attention given to such instruction where it exists: Instruction given in connection with the clinical specialties is sufficient; time for intensive instruction to the already overburdened student is not available; the subject is not important enough to warrant special teaching; and, finally, it is better for the student to learn roentgenology as part of the clinical aspect of

the case. The author discusses and controverts each of these views in turn and shows how necessary and important instruction in the general problems of technique, diagnosis and treatment in roentgenology is to the student.—*W. A. Evans, Jr.*

Holmblad, Edward C. Postero-anterior x-ray view of knee in flexion. *J. Am. M. Ass.*, Oct. 9, 1937, *109*, 1196–1197.

The accurate diagnosis of pathologic conditions of the knee joint is at its best a difficult task before operation. In many cases the clinical history is strongly suggestive of "joint mice," which are not demonstrated on the usual roentgenograms. The joint surfaces are not clear, sharp or well separated. The detail of the upper end of the tibia is not always sharply defined, and incomplete fractures or atypical fractures of the upper tibia extending into the joint may require the superior ability of the expert roentgenologist.

Recently a new position was employed. It was designed to use the intercondylar notch of the femur for better visualization of the tibial spines and attachments of the cruciate ligaments and the knee joint. The view is taken posteroanteriorly with the knee flexed 75 degrees, the tibia nearly paralleling the top of the table. The patient kneels on the table, with the abdomen resting on a stool placed on the table top. In cases in which there is limitation of ankle motion, the foot is permitted to hang over the end of the table, thereby maintaining the lower leg parallel to the top of the cassette or film.—*S. G. Henderson.*

Yngve, Nordheim. Eine neue Methode, den Gelenkknorpel, besonders die Kniegelenkmenisken, röntgenologisch darzustellen (ohne Zuhilfenahme eingespritzten Kontrastmittels). (A new roentgen method for demonstrating the articular cartilages, particularly the knee joint menisci (without using the injection of contrast substances).) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1938. *57*, 479–495.

In 1932 Dittmar reported that the internal meniscus could be made visible under certain conditions when the knee was held in strong abduction position and flexed 160 degrees. In this way the true joint spacing could be shown in a few children and occasionally in adults where pathology was present, i.e. tears in the medial collateral ligament or injuries to the interarticular disc. Demonstrability is easier in children because the ligaments are more flexible and elastic. In 1934 Felsenreich was able in a similar manner to determine the presence of injuries at the medial aspect of the knee. In none of these cases described in the literature was there any effusion into the joint. The author has studied experimentally the possibilities of the method for two and a half years. The principle is the creation of a space of relative vacuum, which contrasts with the joint cartilage, by twisting, pulling or bending the joint beyond the limits of its normal mobility. The fine transparent area which is produced in this manner is, the author believes, a true relative vacuum and not fat tissue or synovia as some have believed. This is proved by serial studies on a knee joint. The vacuum which is seen following sharp abduction disappears in about ten minutes as it is replaced by fluid drawn from the tissues. When there is any appreciable quantity of fluid in the joint (5–10 cc.) this evacuated space, of course, cannot be produced.

In addition to the knee, the joint space is demonstrable in the shoulder joint and in the metacarpophalangeal joints of living subjects. By forceful supination at the shoulder joint, a vacuum is created in the anterior portion and the space is demonstrable as a fine crescent-shaped transparent area. The true metacarpophalangeal joint space becomes visible upon strong traction. It was possible to demonstrate the lateral meniscus of the knee by forced adduction in only 2 out of 30 cases. In demonstrating the medial meniscus, the author recommends that the leg be held by an apparatus in an extended position, and abducted with as much force as the subject can tolerate without pain. His efforts in showing the medial meniscus were successful in 71 of the 100 normal joints. In cases of effusion much information can be gained by aspirating as much of the fluid as possible and injecting 5 cc. of air, with exposures made in various positions to bring the air in contact with the areas in question.—*W. A. Evans, Jr.*

Kerber, Bruno. Experimentelle Studien über venöse Luftembolie. (Experimental studies on venous air emboli.) *Fortschr. a. d. Geb. d. Röntgenstrahlen*, May, 1938, *57*, 439–454.

The behavior of air emboli in the veins of rabbits was studied by autopsy, the roentgen kymograph using the methods of contrast blood, and with the electrocardiogram. The following results were obtained. Air emboli do not pass the lung capillaries and are not found in the chambers of the left heart or in the coronary arteries. A blood-air mixture may be found in the coronary veins and it was observed that the contents of the right auricle may flow out through the incised coronary veins. The rapidly progressive insufficiency of the coronary circulation which occurs in air embolism is produced not so much because of faulty supply to the coronary arteries as because of hindrance to the emptying of the veins. Maintenance of the blood pressure does not improve the coronary flow.—*W. A. Evans, Jr.*

Altschul, Walter. Weitere Erfahrungen mit Radiumchloridinjektionen. (Further experience with radium chloride injections.) *Strahlentherapie*, 1937, *60*, 381.

In the 45th volume of *Strahlentherapie* (1932) the author made a preliminary report on the good effects of radium chloride injections. He tested these injections on the rabbit's eye and found that a dose of 1 mc. had practically no local action. He therefore used this as a therapeutic dose.

As a rule, he gave two series of six injections each; a third series was only rarely necessary. The six injections were generally given on six successive days, the first three being of 1 mc. and the last three of 2 mc. The results were also good if a day of rest was given between injections. As there was some reaction, particularly after the doses of 2 mc., the sites of injection should not be too close together. With these small amounts of radium no deposits are seen in the organs. There is no toxic effect from cumulation with this technique. In multiple joint affections, therefore, several joints can be treated at once.

His results in sciatica have been reported previously. He has also used the method in arthritis of the knee and shoulder joints, rheumatism and neuralgia. Three illustrative cases are described. Cases treated five to six years ago have remained free of recurrence.

The method has not been used as freely as it should be, partly because it is not sufficiently known and partly because it is too expensive. The sick benefit societies will not spend so much money on a new method and many of the patients cannot afford it and besides have some fear of the injections.—*Audrey G. Morgan.*

Belot, J. Nouveau tube de radiothérapie à haute intensité, du type à anticathode extérieure construit par la compagnie générale de radiologie. (New tube for radiotherapy at high intensity with an external anticathode.) *Bull. et mém. Soc. d'électro-radiol. méd de France*, March, 1938, *26*, 153–158.

The anticathode in this tube is placed at one of the ends of the tube; it occupies the bottom of a long copper tube of which the open extremity is soldered to the glass of the tube. At the other end there is a bulb, in the bottom of which is the anticathode. The latter is, therefore, completely outside of the glass tube.

The model just produced by the Compagnie Générale de Radiologie differs from the American product because of a special form of the anticathode. The tube "Curvix type" is oil-immersed and cooled by a pump. It functions at 200 kv. and 25 ma. pulsating or 18 ma. constant potential. The tube is 36 cm. long.

Measurements made with a Hammer dosimeter, with a rice phantom, 40 cm. distance, 15×15 cm. field:

1. Total of 1 mm. copper plus 2 mm. Al, 150 kv., 18 ma. constant potential, 45 r/min.; 175 kv., 18 ma., constant potential, 67.5 r/min.; 200 kv., 18 ma. constant potential, 100 r/min.
2. Total of 2 mm. copper plus 2 mm. Al, 200 kv., 18 ma. constant potential, 58 r/min.—*M. L. Sussman.*

Spiegler, G. Die Röntgendosimetrie, ihre Entwicklung und ihr Stand. (Roentgen dosimetry, its evolution and present status.) *Strahlentherapie*, 1937, *58*, 710–712.

A rather interesting though theoretical discussion of dosimetry is briefly presented. The human error involved in any instrument is likewise inherent in dosimeters. Changes in barometric pressure and temperature may cause 10–12 per cent error; and these factors are possibly accountable for many of our errors. Unfortunately to date, it must be admitted, there is no simple, rapid, practical and reproducible method of controlling the chamber constant. This necessitates comparison with standards reduced from radium exposure, which requires time and considerable effort. The aim is at pres-

ent to model an inexpensive and reliable direct reading dosimeter, which the author thinks can be purchased in the near future.—*W. R. Stecher.*

Strauss, S. Zur Geschichte des Mekapions und dessen heutiger Entwicklungsstand. (The history of the mekapion and its present-day evolutionary state.) *Strahlentherapie*, 1937, *58*, 713–717.

A brief outline of the improvement of this ionization chamber is given showing its final change into the very exact modern instrument. The value of an integrating roentgen dosimeter is discussed, and the various complicating physical factors which had to be overcome before the method was of real practical value. To quote Kant, "there is knowledge only where one can measure," and this is true in radiology, for only when accurate measurement of dosage on the patient is procurable can one expect to reach the goal one constantly strives for.—*W. R. Stecher.*

Root Studio

HENRY SCHMITZ

JANEWAY MEMORIAL LECTURER, 1939

UNIV. OF MICH.